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There are just three weeks to go until our flagship science show. Visit our website to explore the programme of talks, speakers and experiences

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NS Live

Space weather

Hear planetary scientist Suzie Imber discuss how the sun's activity can drive auroras on Earth and the other planets in our solar system, and find out why 2025 will bring an increased probability of bright auroras and other space weather effects on Earth. Visit New Scientist Live on 13 October at London's ExCeL Centre or watch online.

newscientist.com/nslmag

Tour

The science of the Renaissance: Italy

Encounter the great scientific minds and discoveries of the Renaissance, from Filippo Brunelleschi and Sandro Botticelli to polymaths like Leonardo da Vinci and Galileo Galilei. Join art historian Jeremy Boudreau as you explore the beautiful cities of Florence, Pisa and Bologna. This six-day tour begins on 4 November and costs £2479.

newscientist.com/tours

Podcast

CultureLab

Hydrophones – microphones designed to capture underwater audio – are helping scientists unravel hidden soundscapes. In this episode, science writer Amorina Kingdon explores the fascinating ways that marine animals produce sound, the physics of underwater ears and how humans are affecting critical submerged soundscapes. Plus, hear samples of some of the most captivating underwater sounds she has encountered.

newscientist.com/nspod

SHUTTERSTOCK/HARSH.LLL

Bright lights 2025 promises to bring a spate of space weather

LORENZO MARTINCICH/RED BULL CONTENT POOL

Battle of technologies Will electric cars' instant torque win out?

Video

Electric versus petrol

At the Montalegre circuit in Portugal, electric vehicles and combustion-engine cars are racing against each other in an FIA championship event for the first time. Billed as the "battle of technologies", the race sees them compete on equal terms, with each type of vehicle having advantages and disadvantages that must be balanced in order to win.

youtube.com/newscientist

Newsletter

Our Human Story

It is a truism in human evolution that our ancestors came down from the trees and out into more open country like grassy savannahs. In contrast, dense tropical forests have been seen as unfavourable frontiers that were too hostile for humans. Michael Marshall considers the evidence that is overturning this idea.

newscientist.com/our-human-story

A note from the editor

Dear reader,

This time of year is a special one for the *New Scientist* team as we prepare for our annual extravaganza, New Scientist Live, which takes place in just three weeks' time, on 12 and 13 October. If you haven't been before, you can expect a weekend full of incredible talks about cutting-edge science and groundbreaking ideas, a show floor packed with live demonstrations and hands-on activities – and I'm told this year there will be dinosaurs, too. We modestly call it the world's greatest festival of ideas and discoveries.

Last year, I hosted the mind and body stage and I can honestly say the speakers were phenomenal – I still think about their talks to this day. This time round I'm looking forward to hearing regular *New Scientist* contributor David Robson discuss how we can make more meaningful connections and Nobel prizewinner Venki Ramakrishnan talk about ageing. I also can't wait to see the winning entry for our competition with Lego, which will be built on site.

If you would like to come along, early bird tickets for either or both days are still on sale, but be quick, as this offer ends on 22 September. If you can't join us in person, you can also buy an online ticket and enjoy the show from the comfort of your home. To book tickets and for all details of this year's show, visit newscientist.com/nslmag.

All the best, and I hope to see you there.

Catherine de Lange
New Scientist editor

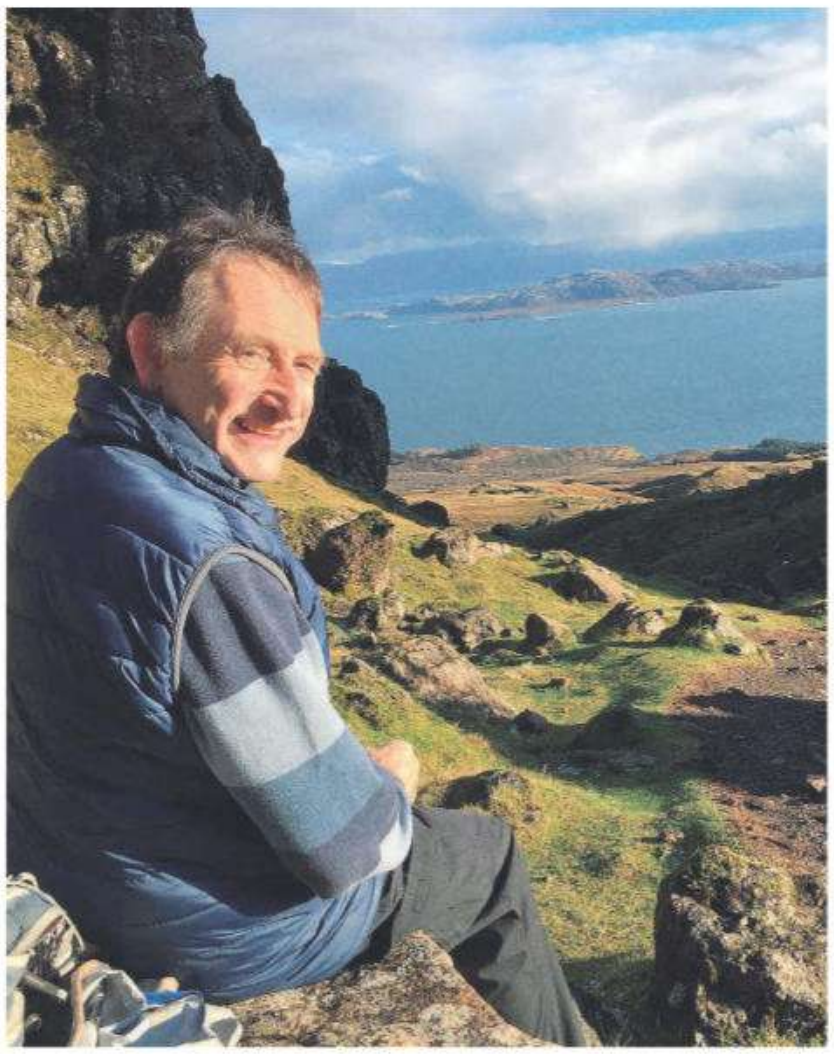
People can be a happy place.

Jo's four children are his. His world is never bigger than with them. Out on a hike. Everyone together. It's when Perthshire is at its most beautiful.

But his favourite bit? When the walk is finally over and the whole family sits down for a proper cup of tea and ever-so-slightly overdone fruit cake.

It's what made his late wife, Sue, happiest. The brood of kids all around her. Stomachs and hearts full. And it's the part he now cherishes most.

That's why he left a gift to Cancer Research UK in his Will.



So more famillies can have more time together.

For **Daniel**, it's been twelve more years with his loved ones – and counting. His Hodgkin Lymphoma diagnosis at just twenty-three was a huge shock. He felt lost, but never alone. His boyfriend Adam holding his hand every step of the way.

After four rounds of chemotherapy and two weeks of radiotherapy, which CRUK pioneered, he was given the all clear.

In 2023, he and Adam celebrate their first anniversary as husband and hubby. Cherishing every anniversary since.

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Safe space?

Current international law isn't fit for today's space industry

IF YOU watched the live video of billionaire Jason Isaacman popping his head out of a SpaceX spacecraft (see page 9), your first thought probably wasn't "who gets sued if something goes wrong?" – but as private spaceflight grows, questions like these must be addressed.

International space law is a patchwork of treaties dating back to the space race, most importantly the Outer Space Treaty of 1967. One key tenet of this is that only states can be responsible for activity in space, even that of "non-governmental entities" like SpaceX. Because Isaacman and his crew launched from the Kennedy Space Centre in Florida, that means the buck stops with the US government.

But the US government has found ways to pass that buck. While the Federal Aviation Administration (FAA) has strict rules and regulations for commercial air travel, commercial spaceflight has always been given a lighter touch, most recently by the SPACE Act of 2015. That law extended a "learning period" that prohibits the FAA from issuing regulations related to the safety of astronauts on private spaceflights. In other words, any safety concerns Isaacman may have had were hashed out between him and SpaceX.

"We may soon see legal clarity on who is responsible for private astronauts"

This learning period is due to expire on 1 January 2025, so we could soon see legal clarity on who is responsible for private astronauts, but this isn't the only area of space legislation that needs attention. Astronomers are increasingly concerned about the number of satellites in orbit, potentially ruining their observations (see page 15). Elon Musk's SpaceX is again a big player here, controlling two thirds of active satellites – and there are currently no regulations that prevent him from launching as many as he pleases.

So what next? As policy researcher Thomas Hale says (see page 21), our political systems aren't designed to solve "long problems", and they don't get much longer than taming the final frontier. That isn't to say we shouldn't try, however – and a refresh of the ageing Outer Space Treaty to help tackle these more modern issues would be very welcome. ▮

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Technology

The pharmabot will see you now

This Galbot G1 robot is picking up a box of medicine as part of a demonstration at the 2024 China International Fair for Trade in Services on 12 September in Beijing. The robot is equipped with an artificial intelligence system that helps it grab specific items, fold clothes and open drawers. Beijing-based robotics start-up Galbot plans to introduce its robots into industries with high labour costs.

ZHAO WENYU/CHINA NEWS SERVICE/VCG VIA GETTY IMAGES

Environment

Stormy with a dash of climate change

Thanks to advances in weather simulation, forecasts of extreme events could soon come with information about how much they were fuelled by growing emissions, finds **Madeleine Cuff**

A REVOLUTION in weather forecasting could soon see warnings of forthcoming heatwaves, storms or other extreme events accompanied by specific information on the role climate change has played in fuelling them. The shift would help meteorologists bring the reality of our warming planet home to the general public.

Key to this idea is the growing field of attribution science, which involves examining extreme weather events after the fact to quantify the impact of climate change. It involves simulating an event twice, under real-world conditions and in a fictional world where there is no human-caused climate change. The difference between those two scenarios reveals the extent to which rising emissions made matters worse.

Such attribution used to take months, but techniques have improved dramatically in recent years, to the point where it can be done just days after an event. Now, researchers want to go further and apply attribution science to events before they even happen.

At the UK weather service, the Met Office, Peter Stott and his colleagues are doing this with high-resolution, state-of-the-art weather forecasting models,

"The dream is to say that an upcoming heatwave will be this much worse due to climate change"

rather than the more grainy climate models used for after-the-event attribution. In essence, they are using the models to compare real-world forecasts with ones based on a fictional world unaffected by human influence. "We are very interested in this forecast attribution idea," he says.

The goal, says Stott, is to

NATHAN CONGLETON/NBC/GETTY IMAGES

Factoring in climate change would make current weather forecasts more striking

provide the public with weather and climate information at the same time. "So, the forecast, the information about how this relates to climate change, and the impacts it means for them locally... all of that is coherent and consistent... and available in advance of what's about to hit."

While Stott's team is still testing the approach, a pilot of sorts has already inadvertently taken place. In 2022, the UK had record-breaking temperatures over 40°C (104°F). By chance, the Met Office had recently finished an analysis looking at how climate change had influenced the chances of the UK seeing such extreme heat.

That attribution analysis was included in public messaging of the heat forecasts, says Stott, to "support the narrative" that this was rare, dangerous weather for the UK. "We brought in the attribution to say the 40°C heat was not just unprecedented, but something that you wouldn't expect without climate change."

However, using traditional weather forecasting models to run attribution analysis is time-consuming and requires access to specialist computing systems because they involve crunching through large numbers of physics-based calculations.

The power of AI

Bernat Jiménez-Esteve at the Institute of GeoSciences, Madrid, Spain, has experimented with a different approach, using artificial intelligence-powered weather forecasts instead. These AI models are trained on data from regular physics-based climate models, but then use statistical extrapolations to make weather forecasts.

Like the Met Office's approach, using AI for attribution analysis means forecasting extreme events under real-world and fictional pre-industrial conditions to compare them, but it can be done more quickly, says Jiménez-Esteve. "It's at least two orders of magnitude faster than a conventional operational weather model."

Together with colleagues, he ran the AI-enabled approach on three past extreme events: the 2018 Iberian heatwave, Hurricane Florence, which hit the US in 2018, and Storm Ciaran, which swept through the UK and other parts of northern Europe in 2023.

The AI models correctly predicted that all three extreme events would occur, but underestimated their size. The forecast-based attributions concluded that climate change made the Iberian heatwave about 1.5°C warmer than it would have been in a pre-industrial world, while Hurricane Florence was stronger, wetter and slightly larger than it would have been, and Storm Ciaran had stronger winds.

Jiménez-Esteve says the AI approach is currently most accurate when considering heatwaves. It is more limited for complex systems such as a tropical storm, in part because the models used to train the AIs weren't of high enough resolution to capture small-scale processes such as those at the centre of a hurricane.

That is one of the drawbacks of using AI systems trained on climate models, says Stott, rather than high-resolution weather forecasting models. "The dataset they are using is on a coarser grid than we would use on our weather forecasts," he says. "So you are missing some of the details of the weather, and that could be crucial not just for forecasting, but also for the attribution."

But Jiménez-Esteve says AI weather forecasts are rapidly improving. "This field is evolving very fast," he says. "Only a few years ago there were not even AI models able to do weather

forecasting... I could see that they will get as good as conventional weather and climate models."

He says this AI-based approach would allow attribution analysis to be much more widely used, helping to expand people's understanding of how extreme events are changing.

Backfiring risk

There is a wider issue with doing attribution analysis on weather forecasts, says Clair Barnes at University College London, who is a member of the World Weather Attribution initiative that performs analyses after extreme events. Feedback effects from a warming world, such as rising sea temperatures, aren't necessarily accounted for by weather models that just tweak atmospheric conditions, she points out, meaning they could provide an incomplete picture. "If you are only changing the atmospheric state, then you are only capturing the effects of the change in the atmospheric state," she says.

Barnes is also concerned about forecasts backfiring if a predicted event fails to emerge. "If you are communicating an attribution result to an event that doesn't actually happen, what does that do to people's understanding of how people perceive the field, perceive climate change?" she says.

Nevertheless, she thinks such additions to weather forecasts could be powerful. "The dream for forecast attribution would be to have meteorologists on the weather forecast, saying 'there's going to be a heatwave and it's going to be this much worse because of climate change'," she says. "When you are trying to communicate the effects of climate change to people, that kind of thing can be really powerful." ▮

Polaris Dawn mission is one giant leap for private space flight

The success of SpaceX's civilian spacewalk shows that private firms are catching up with government space agencies, says **Leah Crane**

SPACEX'S Polaris Dawn mission is a leap forward for private space flight, even though it demonstrates the same capabilities that government space agencies have had for decades. The mission, which splashed down off the coast of Florida at 03:37 local time on 15 September, included the first ever spacewalk, also called an extravehicular activity or EVA, performed by private individuals.

This spacewalk was particularly risky. Unlike the International Space Station (ISS), the SpaceX's Crew Dragon craft doesn't have an airlock, so performing the EVA meant evacuating the entire capsule of air before two of the crew members, Jared Isaacman and Sarah Gillis, ventured out into the vacuum of space. Not only were there no government-trained astronauts on the crew, it was also the first time SpaceX's new spacesuits and the spacecraft itself had been tested in this way.

On its own, this may seem a bit unimpressive. After all, astronauts perform hours-long EVAs on the ISS regularly and have been doing so for decades. Even opening an entire crew capsule to space was relatively common during NASA's Gemini programme in the 1960s.

So it could be said that SpaceX is rehashing old achievements – but that isn't the whole story. "When you are doing something for the first time, it doesn't matter that other people have already done it," says Laura Forczyk, an independent consultant in the space industry.

"SpaceX has never done this before, so they have to start from scratch and take baby steps"

"SpaceX has never done this before, so they have to start from scratch and take baby steps because that's the safe thing to do."

The EVA on 12 September went smoothly, although its characterisation as a spacewalk has faced some criticism from the public, because the astronauts didn't fully leave the capsule. Instead, each participant stuck their torso out of the hatch in what is called a "stand-up spacewalk" for a few minutes. "That was maybe the one thing that went wrong, the communication with the public," says Forczyk. "But this wasn't a public mission – this was a private mission that did not need to communicate with the public."

The key goal of the spacewalk was to test the new suits – a new EVA suit hasn't been used in decades, and NASA's supply is limited and ageing. "SpaceX has now demonstrated that these suits are safe in microgravity, so the big question now is whether SpaceX intends to sell spacesuits to NASA," says Forczyk. If so, even this relatively simple stand-up EVA test could help overcome a major obstacle in human space flight.

Aside from testing the suit, the crew members have also been participating in an array of health experiments to determine the effects of space travel on the body. These range from tracking bone and muscle loss during the flight to imaging their brains and other organs after the return to Earth.

"Civilian space missions like this one can actually really help us move the needle on studying human health in space flight," says Rihana Bokhari at the Translational Research Institute for Space Health in Texas. That is partly because more missions will mean more people in space and more data.

Now the space travellers have returned, their health, capsule and suits will be evaluated. The next flight in SpaceX's Polaris programme isn't yet set, but it may only be a matter of time before the firm catches up to the government agencies that have been the only superpowers in space for so long. ▮

Polaris's crew vented air out of the capsule (below) before Jared Isaacman (below right) popped out into space

SPACEX HANDOUT/EPA-EFE/SHUTTERSTOCK

Neuroscience

First map of the pregnant brain

A woman's brain has been scanned throughout her pregnancy, adding to evidence that dramatic remodelling takes place in preparation for motherhood, finds **Helen Thomson**

THE human brain goes through significant changes during pregnancy with few regions untouched, according to the first ever map of this over the course of gestation and beyond.

Some areas of the brain shrink during this time, while others grow and become better connected. These changes are thought to enable mothers to develop strong bonds with their baby and adapt to the demanding task of caring for them. A better understanding of this remodelling could explain several pregnancy-related behaviours and help people at risk of mental health conditions, such as postnatal depression.

"The maternal brain undergoes a choreographed change across gestation, and we are finally able to see it unfold," says Emily Jacobs at the University of California, Santa Barbara, whose team carried out the work.

"The brain undergoes a choreographed change, and we are finally able to see it unfold"

Previous studies have taken snapshots of the brain during pregnancy, but it has remained a mystery how it alters over this time and beyond. To find out, Jacobs and her colleagues scanned the brain of a 38-year-old, first-time mother 26 times, starting from three weeks before conception through to two years after giving birth.

The most pronounced changes occurred in the brain's grey matter, the wrinkly outer layer that is packed with neuron cell bodies and synapses, the junctions between the cells. The woman's grey matter volume decreased, but its connections multiplied.

This major remodelling, sometimes called neuroplasticity, occurred in grey matter across the brain at three times the rate seen in eight non-pregnant women who also had their brains scanned over the same time.

OLENA SMYRNOVA/LABART.COM.UA/GETTY IMAGES

Maternal brain changes might help with bonding

"Sometimes people bristle when they hear that grey matter volume decreases across pregnancy, but this isn't necessarily a bad thing," says Jacobs. Think of the brain a bit like Michelangelo's *David*: a big block of marble had to be chipped away to create the beautiful sculpture, she says. A similar thing happens in the brain, with the changes probably reflecting a fine-tuning of brain circuits, as occurs during puberty when the brain becomes more specialised.

DANIELA COSSIO

White matter tracts (coloured lines) are modified in a pregnant woman's brain

The study also found increases in white matter, the nerve fibres that connect neurons and help various brain areas communicate. This peaked in the second trimester of pregnancy, then returned to pre-conception levels after the baby was born. The changes were particularly noticeable in regions associated with sensory attention, emotion, self-directed thought and introspection (*Nature Neuroscience*, DOI: 10.1038/s41593-024-01741-0).

"All in all, this supports the reconceptualisation of motherhood as one of the periods of highest neuroplasticity in adult life," says Susana Cañabate at Gregorio Marañón Hospital in Madrid, Spain.

This brain remodelling probably enables certain maternal behaviours. For instance, in rodents, increases in steroid hormones during pregnancy trigger brain changes that enhance the mother's sensitivity to smells and sounds from her pups.

Studies suggest something similar happens in people. For instance, in 2017, researchers showed that the magnitude of change in grey matter volume corresponds with the degree of parental attachment. But there is also work that shows how brain changes during pregnancy confer a vulnerability to some mental health conditions.

The new study boosts our knowledge of pregnancy-related brain changes, but doesn't tell us how they link to behaviour, says Jacobs. It isn't clear, for example, why white matter changes revert to pre-pregnancy levels while some grey matter changes persist.

Baby steps of knowledge

It may be that the longer-term changes are associated with behaviours important to the survival of the child, such as eliciting maternal behaviour. But Jacobs points out that parents who use surrogates, adoptive parents and fathers still display the nurturing behaviours needed to care for their child.

We need more research to grasp the impact of the changes, says Elseline Hoekzema at Amsterdam University Medical Centre in the Netherlands. Her work has shown brain changes link to a parent's responsiveness to their child's cry.

The next step may be to analyse how the timing of brain alterations differs between individuals, says Cañabate. This might help explain why some people struggle to bond with their babies or develop mental health conditions, she says. It will only be possible to test any potential interventions when we understand the causal factors, how they link to hormones and the subsequent consequences. ▮

Earth science

Greenland landslide caused a freak wave that shook Earth for nine days

Michael Le Page

ON 16 September 2023, seismic monitoring stations around the world noticed a strange signal that faded over time but remained detectable for nine days.

"We were like, 'Oh wow, this signal is still coming in. This is completely different to an earthquake'," says Stephen Hicks at University College London. "We called it an unidentified seismic object, or USO."

Hicks and his colleagues have now shown that this signal was caused by water sloshing from side to side across the 2.7-kilometre-wide Dickson fjord in eastern Greenland. This wave was triggered by a massive landslide that resulted in a 110-metre-high tsunami.

Earthquake signals usually last only minutes and are a mix of different frequencies, says Hicks. The USO had a single frequency of around 11 millihertz, meaning it repeated every 90 seconds. Once it became clear that the signal began at the same time as the Greenland landslide, the researchers realised there was probably a connection.

Many objects, such as a bell, will vibrate at a particular resonant frequency if struck. The same is true of bodies of water, from swimming pools to oceans. Disturbances such as earthquakes and winds can set them rocking, generating a kind of standing wave known as a seiche.

Based on its width and depth, the researchers calculated that the resonant frequency of Dickson fjord is 11 millihertz – matching the signal. What took them longer to understand is why the fjord kept rocking for so long (*Science*, doi.org/nhgv).

Immediately after the tsunami, the seiche was going up 7 metres on either side of the fjord. Within days, it had gone down to a few centimetres – so small that a Danish naval boat that went up the fjord three days after the landslide didn't notice it.

But the seiche kept going and probably persisted long after the nine days, when it was no longer detectable by distant seismic stations, says Hicks. "No one has ever reported seiches lasting for so long."

Dickson fjord in Greenland after a landslide in September 2023

COPERNICUS, SENTINEL-2, EO BROWSER

The shape of the fjord was a crucial factor, computer modelling by the team shows. The landslide site is 200 kilometres inland, with a glacier blocking one end of the fjord and a sharp bend at the other. The round bottom of the fjord also acted a bit like a rocking chair, allowing the water to move with little resistance.

All these factors resulted in a high degree of energy trapping, says Hicks, instead of the wave rapidly dissipating as usual.

The landslide itself was a direct result of climate change. A steep glacier was helping to hold up a mountainside. As the glacier thinned, it gave way, resulting in about 25 million cubic metres of rock and ice falling into the fjord.

As the planet warms, there will be more landslides like this, says Hicks. Global warming isn't just affecting the atmosphere and oceans, he says. "For the first time, we're looking down beneath our feet to see some of the catastrophic impacts of climate change." ▮

Technology

The types of deepfakes that con us most easily

PEOPLE can generally spot when videos of famous politicians giving speeches are actually AI-generated deepfakes. But we have slightly more trouble identifying counterfeits when listening to audio, and struggle when reading fake text transcripts.

"Audio deepfakes are, in my opinion, a little more dangerous in the current time because visual deepfakes are still harder to create," says Aruna Sankaranarayanan at the Massachusetts Institute of Technology.

Sankaranarayanan and her colleagues collected text transcripts, audio and video of political speeches given by US presidents Joe Biden and Donald Trump. They also created deepfake speeches and misattributed text quotes to them that had come from other public figures. The text was edited to match the speaking style of either Biden or Trump. Then the researchers ran five randomised experiments that exposed more than 2200 people to a mix of the authentic and artificial content.

People had the most trouble identifying fake political speeches written as text transcripts, calling out the false information with just 57 per cent accuracy. The detection accuracy rose to 69 per cent when viewing silent videos without audio or subtitles, 81 per cent for audio only and 86 per cent for video deepfakes with audio (*Nature Communications*, doi.org/nhgw).

"The authors meaningfully point out how text – a domain for which we have more limited interventions for authenticating content than for visual content – may actually be more effective for misleading people than visuals," says Claire Leibowicz at the Partnership on AI, a non-profit group in San Francisco.

"Audio deepfakes are, in my opinion, a little more dangerous in the current time"

One experiment gauged responses to sophisticated video deepfakes that obtained their audio in different ways: either AI-powered voice cloning technology or human actors doing impressions. The fakes with AI voices were harder to detect than the ones with human audio. ▮

Jeremy Hsu

Astrobiology

Complex chemicals found on Enceladus improve prospects for finding life there

Alex Wilkins

SATURN'S moon Enceladus appears to have a greater range of complex organic molecules than previously thought, increasing the likelihood of chemical reactions that produce the building blocks of life.

Enceladus is one of the most promising places for life to exist elsewhere in our solar system. It has a vast liquid ocean underneath its icy crust, from which plumes of ice and vapour erupt, and there is evidence of energy sources on the seabed, like the hydrothermal vents in Earth's oceans.

The spacecraft Cassini, which orbited Saturn and its moons for 13 years before smashing into the planet in 2017, sampled icy rock grains in one of Saturn's outer rings, which are thought to come from Enceladus's plumes.

Those samples, studied with the probe's Cosmic Dust Analyzer, have previously confirmed that Enceladus has all six of the chemical elements needed for life as we know it: carbon, hydrogen, nitrogen, oxygen, phosphorus and sulphur. Cassini also made a closer flyby of the moon, collecting grains from the plumes themselves, but these have been less closely analysed.

Now, in a new look at the data Cassini sent back about the plume samples, Nozair Khawaja at the Free University of Berlin and his colleagues have found evidence of a wide range of chemical groups that are common to many biological molecules.

They included esters, alkenes and ethers, as well as complex molecules containing nitrogen and oxygen, Khawaja told the Europlanet Science Congress in Berlin on 11 September.

While the researchers can't pinpoint exactly which molecules these chemical groups came from, their presence means there are more possible pathways for chemical reactions to produce fats or nucleotide bases, the building blocks of DNA.

One reason why these chemicals weren't detected in Saturn's ring is that Cassini detected less water in the ice grains near the plumes, so Khawaja and his team could identify the organic chemical signatures more clearly.

"We knew already from analysis that had been done before that there were heavier molecules, but this is going into more detail about exactly what they might be," says Andrew Coates at University College London.

"The presence of these molecules means there are more ways for producing the building blocks of DNA"

This helps bolster the idea that Enceladus could host life, says Coates, but it will be very hard to establish exactly what molecules are in these grains, because of the technical limitations of the tools that were on board Cassini. "It wasn't designed to actually look for life, but more information about building blocks for life is certainly something which will keep us going for some time." ▮

New Scientist Live

Signals from the beginning of the universe

Hear Jo Dunkley discuss the universe's fundamental ingredients on 13 October newscientist.com/nslmag

Neuroscience

Crocheted hats help record the brain activity of cats

SCIENTISTS have recorded electrical activity in the brains of awake cats for the first time, thanks to specially crocheted wool caps that hold the electrodes in place.

The technique gives researchers a way to assess chronic pain in cats and could lead to novel treatments, says Aude Castel at the University of Montreal in Canada.

About a quarter of all adult cats live with chronic pain due to osteoarthritis, which gets worse with age. Because treatment options are limited and generally involve significant side effects, Castel and her colleagues have been seeking alternative ways to relieve pain in cats, such as aromatherapy.

Electroencephalograms (EEGs) can be helpful in assessing the effects of such treatments because they can show the brain's responses to pain and to stimulation of the senses. Thus far, though, the only EEGs carried out in cats have been performed in sedated animals.

Castel and her colleagues attempted to place electrodes on the heads of 11 awake, adult cats – all of which had osteoarthritis – in order to record their brain activity in response to smelling a variety of substances and seeing different wavelengths of light.

However, the cats regularly shook their heads, causing the electrodes to shift out of place or fall off. Finally, the researchers realised they could take advantage of a new fashion for cats: crocheted caps.

"When you spend more time putting electrodes back on than you do actually recording the EEGs, you get creative," says team member Aliénor Delsart, also at the University of Montreal.

The team asked a graduate student to crochet special cat caps to hold the electrodes, inspired by a tutorial on YouTube. With the new hats in place, the researchers found that the electrodes stayed in position and that the cats no longer tried to play with or chew the wires.

A cat wearing a crocheted hat custom-made to record brain activity

ALIÉNOR DELSART

The EEG recordings in the awake cats were mostly usable, although a few still had too much interference from their head movements. Even so, the results allowed the team to determine critical brain activity related to the cats' pain levels and reactions to various smells and coloured lighting (*Journal of Neuroscience Methods*, doi.org/nhhv).

As such, the team plans to use the EEG caps in future studies to determine how various treatments – including drugs and alternative therapies like odours and lighting – affect the cats' perception of pain, says Delsart. ▮

Christa Lesté-Lasserre

Physics

Causality still works in quantum world

The direction of cause and effect for quantum objects was brought into question more than a decade ago, but new calculations offer a way to restore it, says **Karmela Padavic-Callaghan**

VINK FAN/SHUTTERSTOCK

The quantum realm follows different rules from those of classical physics

FIRST comes cause, then comes effect – or does it? This order of events has previously been upended in the quantum realm, with the possibility of both A-causes-B and B-causes-A happening simultaneously. But a new mathematical analysis suggests this quantum quirk may be hemmed in by the very structure of space-time.

For more than a decade, physicists have been grappling with the idea of indefinite causal order – instances where it is impossible to tell whether cause came before effect or vice versa because the two scenarios are in a quantum superposition where both and neither are true at the same time.

Strikingly, a 2017 experiment showed that a particle of light can pass through two gates such that it is impossible to tell which it went through first. This further established indefinite causal order as an unavoidable oddity of quantum theory.

"Causality is central to how we explain how things work. We observe things around us and want to ask, 'Why does that happen?'," says V. Vilasini at Grenoble Alpes University in France.

To investigate causality further, she and Renato Renner at ETH Zurich in Switzerland were informed by two foundational theories. The first is quantum information theory, in which cause and effect are connected by the flow of information. The second is Albert Einstein's special theory of relativity, which suggests that all causal influence must be slower than the speed of light (*Physical Review Letters*, doi.org/nhgz).

This second constraint describes the space-time we live in and bakes into its structure a clear notion of before and after.

A smear in space-time

Experiments that feature indefinite causality happen in that same space-time, yet seem to contradict this structure, says Christina Giarmatzi at Macquarie University in Australia.

Vilasini and Renner derived two theorems that aim to reconcile this contradiction. The first states that for causality to be muddled, information about an object in question must become non-localised – smeared out in space-time instead of contained in one place, such as a detector (*Physical Review A*, doi.org/nhg2).

"Remarkably, Alice becoming soup isn't forbidden by quantum mechanics"

Say two people, Alice and Bob, are exchanging a particle of light to which conventional causality may not apply. For the particle to arrive before she sends it, Alice would have to "become soup", says Pablo Arrighi at Paris-Saclay University. Remarkably, Alice becoming soup isn't forbidden by quantum mechanics.

But the second theorem is more prohibitive. In it, the team found that if you are able to look at a process closely enough, you will see causality eventually emerge among its finer details.

We can think of A-causes-B in a more granular way: A is actually a series of events called A1, A2 and A3, while B is similarly split up. We may see A-causes-B and also B-causes-A, but, upon closer inspection, it could be that A1 causes B1, B2 causes A2 and A3 causes B3.

Renner says that all experiments to date that have reported indefinite causal order could be reinterpreted as causal by a similar zooming-in.

Časlav Brukner at the University of Vienna in Austria says that while it may be possible for researchers to obtain more information through this type of fine-grained approach, this information may not be relevant for light particles or other quantum objects. Brukner doesn't question the findings, just their implications. "If the mathematics of a theorem is correct, then it must be correct. But what it means, and when it's relevant, this is where we can disagree," he says.

Arrighi says that staking a definite position on the plausibility of indefinite casual order in any particular experiment may come down to how a researcher interprets quantum theory itself. For Giarmatzi, the issue may only be resolved with more experiments.

However, Arrighi says the two theorems invite examinations of how relativity and quantum theory can combine. Specifically, the work doesn't explore what could happen if space-time itself were quantum.

This opens the tantalising possibility that within a fully fledged theory of quantum gravity, which physicists have been seeking for decades, causality could once again be in peril. ▮

Climate change

Low sea ice levels signal permanent shift in Antarctica

James Dinneen

FOR the second year in a row, Antarctic sea ice has reached near-record low levels. This reinforces concerns that climate change has initiated a lasting "regime shift" in the amount of ice that forms in the Southern Ocean each year.

"Last year we were talking about whether Antarctic sea ice is undergoing a regime shift. Not any more," says Edward Doddridge at the Institute for Marine and Antarctic Studies in Australia. "Antarctica has pretty definitively answered that question for us. Now we are talking about what the impacts of that regime shift will be."

1.4 m
Area of missing Antarctic sea ice, in square kilometres

In early 2023, researchers were shocked when the sea ice encircling Antarctica smashed the previous record low set in February 2022 in the southern summer. It remained far below average levels as it expanded through the southern winter of 2023. That same pattern has repeated in 2024. In February this year, the ice reached the second lowest extent on record and it has stayed around 8 per cent below average levels.

Though there has generally been more ice than 2023, on 7 September, its coverage dipped below last year's levels. It set a new record low for that day with an extent of just 17 million square kilometres, according to a release from the Australian Antarctic Program Partnership. That is about 1.4 million square kilometres below the long-term average for that time of year – an expanse of missing ice roughly twice the size of Texas.

The coverage has expanded a bit over the past few days, but the persistently low levels suggest a more lasting change is occurring, says Caroline Holmes at the British Antarctic Survey. "The evidence is building for something like a regime shift," she says.

Distinguishing natural variability from the influence of human-caused climate change is difficult due to unreliable sea ice models and a relatively short 45-year satellite record of sea ice extent. However, it is "plausible that this is the start of a climate change signal in Antarctic sea ice", says Holmes.

A sustained increase in ocean heat in particular appears to be driving the change, with waters too warm to freeze, says Zachary Kaufman at Stanford University in California. However, he says the "jury is still out" on whether the response of the ice is a permanent change or just a blip.

Either way, the lack of sea ice could have consequences for Antarctic ecosystems. It affects animals like seals and penguins that live on the ice, as well as the photosynthetic plankton that form the base of the food web.

"If you have repeating seasons like this, then it's hugely impactful for populations that depend on sea ice for [their] habitat and breeding cycle," says Catherine Walker at the Woods Hole Oceanographic Institution in Massachusetts. Less sea ice could also affect global ocean circulation by reducing the amount of cold, dense Antarctic "bottom water", says Walker. "That was expected at some point, but not this soon."

A more speculative effect is how the loss of sea ice might boost the amount of carbon dioxide emitted by the Southern Ocean. During the southern winter, some parts of the ocean contain higher concentrations of CO_2 than the atmosphere does, and sea ice can act like a "lid" that stops the greenhouse gas from being released, says Doddridge. "Such massive reductions in wintertime sea ice raise really big questions about the future of the Southern Ocean carbon cycle," he says. ▮

SERGIO PITAMITZ/VWPICS/ALAMY

Sea ice in the Weddell Sea in Antarctica

Zoology

Tiny chameleon spotted by tourists in Madagascar

Ryan Truscott

ANDOLALAO RAKOTOARISON

A minuscule *Brookesia nofy* leaf chameleon

A NEW species of leaf chameleon, measuring less than half the length of a human forefinger, has been described in a tiny patch of Madagascar's highly threatened coastal rainforests.

Miguel Vences at the Technical University of Braunschweig in Germany and his colleagues were alerted to its presence by tourists posting photos of the tiny reptiles on the internet. Vences's Malagasy collaborators, Andolalao Rakotoarison and Alida Frankline Hasiniaina, went looking for it and collected the first specimen.

Leaf chameleons, from the genus *Brookesia*, are miniature chameleons the colour of fallen leaves that have been breaking records for their small body sizes in recent years. *Brookesia nana*, for example, described in northern Madagascar in 2021, is just 22 millimetres long and is thought to be the world's smallest reptile.

The new species, named *Brookesia nofy* after the Ankanin'ny Nofy tourist site where it was found, is only slightly bigger at around 33 millimetres long (*Zootaxa*, doi.org/nhrp). It is the first leaf chameleon to be found living in coastal rainforests, arguably the island's most threatened habitat.

It is possible *B. nofy* has survived only because the area it was found in is part of a private reserve run by a hotel whose owners have allowed trees to regenerate for 20 years. ▮

New Scientist Live

What's the weather in space?
See Suzie Imber on 13 October, explaining how solar activity can drive auroras on Earth **newscientist.com/nslmag**

Space

Satellite launch raises astronomy fears

Constellations of craft that are brighter than most stars could have a catastrophic impact

Matthew Sparkes

AN UNUSUALLY reflective communications satellite that outshines almost every star in the sky was joined by another five last week. Astronomers warn that the appearance of more and more bright objects in the night sky will severely hinder their work and could even limit our ability to spot asteroids heading for Earth.

Texas-based AST SpaceMobile launched a test satellite called BlueWalker 3 in 2022, drawing criticism from astronomers who found that it was brighter than all but seven stars in the night sky.

AST SpaceMobile intends to assemble a fleet of about 100 satellites to provide mobile phone connections around the globe. The reason for their unusual reflectiveness, which is far higher than most communications satellites, is that they include a 64-square-metre reflective antenna that inadvertently acts like a mirror for visible light.

The company launched the first five commercial versions of BlueWalker 3, called BlueBirds, from Cape Canaveral, Florida, on 12 September. Last year, the firm said it was exploring options to mitigate the impact on astronomy,

"The increasing number of satellites in low Earth orbit is an existential problem for astronomy"

but didn't respond to a request for interview from *New Scientist* about the latest launch.

Grant Tremblay at the Harvard & Smithsonian Center for Astrophysics in Massachusetts, who is vice president of the American Astronomical Society, says the increasing number of satellites in low Earth orbit "is an existential problem for astronomy". While AST SpaceMobile is a concern to astronomers because of its very reflective design, it is by no means the only one, he says. Internet firm Starlink is another whose satellites have raised worries.

"For astronomy, things are absolutely tangibly getting worse," says Tremblay. "I fear that we're at risk of losing the sky."

Projects such as the Vera C. Rubin Observatory, under construction in Chile and due to start scanning the sky in 2025, will have images spoiled by bright streaks when satellites cross their field of view, says Tremblay.

"When a frame is contaminated by, for example, a Starlink crossing, the frame is useless. You throw it out," he says. "The observatory will still work. It'll still do amazing science. But efficiency could drop off a cliff if we start heading into a regime in which hundreds or thousands of reflecting – this size or larger – satellites are in orbit."

Tremblay believes this is a loss to science, but also to wider society. "We return images of this incredibly magical universe whose scale is truly unimaginable, and there's something unifying in that and inspirational in that. If we lose that, I think that's a societal catastrophe."

To solve the problem, he says astronomers may have to put more telescopes in space beyond our cluttered orbit, but the cost and complexity of doing that is generally prohibitive.

Losing astronomical capabilities could even put humanity in danger, others have warned. Ian Carnelli at the European Space Agency says we have spent decades improving our ability to spot asteroids heading for Earth and potentially divert them with projects like NASA's DART spacecraft. "It could be harder to find them in the future [because of reflective satellite constellations], for sure," he says. ▮

Environment

Smog and heat turn most cities into 'wet islands'

MANY cities around the world get more rain than their surroundings. "Just like the way you have an urban heat island, you have an urban rainfall effect," says Dev Niyogi at the University of Texas at Austin.

Niyogi and his colleagues looked at satellite data on rainfall between 2001 and 2020 in 1056 cities and nearby rural areas across different climate regions.

They found that more than 60 per cent of cities were "wet islands", while some other cities were "dry islands". For example, Ho Chi Minh City and Sydney were among the wettest anomalies, each with over 100 millimetres more rainfall than their surroundings per year. Seattle and Rio de Janeiro were among the 10 driest.

Cities can boost or suppress rainfall in several ways. Heat absorbed by asphalt and buildings can cause updrafts that help rain clouds to form. The "roughness" of buildings can slow weather systems so they rain over urban areas for longer. Air pollution can seed clouds, although it can also suppress precipitation by cooling the air. Paved surfaces with little vegetation can reduce evaporation, leading to less moisture in the air.

The influence of these factors varies based on the size and location of cities. The team found larger, more populous cities were more likely to be wet islands.

ALL THEMES/SHUTTERSTOCK

Keeping dry in city centres may be harder than in surrounding areas

Cities in temperate, tropical and coastal regions tended to have the largest anomalies, while those in mountainous areas generally saw smaller disparities (*PNAS*, doi.org/nhdp).

They also found the average difference between wet islands and their surroundings almost doubled over the study period, from 37 to 62 millimetres more rainfall per year. Dry anomalies didn't change. Niyogi says this is because of rapid urbanisation combined with warming temperatures due to climate change, which increase the amount of water vapour in the air.

Current weather and climate models don't fully account for the influence of cities on rain. But Niyogi says it may eventually be possible for city planners to consider how their decisions affect rainfall. ▮

James Dinneen

Health

One vaccine dose can curb mpox

A single shot of a smallpox vaccine cuts the risk of getting mpox, but two would probably be better

Christa Lesté-Lasserre

RECEIVING a single dose of one type of smallpox vaccine seems to lower the risk of catching mpox by about 60 per cent, although this may vary depending on the variant of the virus.

The vaccines used to protect against mpox, formerly known as monkeypox, were originally developed for smallpox. While the two viruses are related, the efficacy for mpox is unclear.

To learn more, Sharmistha Mishra at the Institute for Clinical Evaluative Sciences in Toronto, Canada, and her team focused on a vaccine called MVA-BN, also known as JYNNEOS, Imvanex and Imvamune. This was the most widely used smallpox vaccine in Western countries during the 2022 mpox outbreak, which was caused by the clade IIb variant. A different variant called clade Ib is currently driving mpox cases in the Democratic Republic of the Congo.

Research suggests that MVA-BN's efficacy for mpox varies hugely, from 36 per cent to 86 per cent. That range could be due to the studies being observational and comparing the outcomes of people with different ages, locations and health statuses.

Randomised control trials are under way among men who have sex with men, who made up the majority of infections in Western countries in the 2022 outbreak.

In the meantime, Mishra's team has attempted to mimic a randomised controlled trial by using existing medical data. The researchers looked at more than 6000 men in Canada who were deemed to be at high risk of an infection in 2022. About half had one dose of MVA-BN, while the rest hadn't received any mpox vaccine.

MVA-BN's official regimen calls for two doses administered at least 28 days apart, but the Canadian government initially opted for a single vaccine protocol to spread doses out to as many at-risk people as possible, says Mishra.

Over a follow-up period of around 80 days, 50 men in the unvaccinated group were diagnosed with mpox, compared with 21 in the vaccinated group, which suggests that MVA-BN lowered the risk by 58 per cent (*The BMJ*, doi.org/nhbj).

A man is vaccinated against mpox in Montreal, Canada, during the 2022 outbreak

REUTERS/CHRISTINNE MUSCHI

This is a good level of protection for a single dose, says Adam Hacker at the Coalition for Epidemic Preparedness Innovations in London. "Scientifically, we know that two doses would have a higher efficacy."

Corine Geurts van Kessel at Erasmus MC in the Netherlands says the team's approach was a good way of mimicking a randomised controlled trial, but we don't know whether some of the men in their mid-50s or older had been vaccinated against smallpox when it was a threat, which could have affected their immune response.

Studying how the vaccine affects the severity of illness in people who already have mpox would also help us assess its efficacy, she says. We also don't know how well MVA-BN works against clade Ib, which continues to circulate in West and Central Africa, says Geurts van Kessel, but she expects it to be as effective. ▮

Astronomy

Huge volcano bursts through surface of Jupiter's moon Io

A FRESH volcano with lava flows spanning hundreds of kilometres has appeared on Jupiter's moon Io. It has formed in the 27 years between flybys of two spacecraft.

Astronomers first took detailed photos of Io, the most volcanically active body in the solar system, with NASA's Galileo spacecraft, which was studying Jupiter and its moons between 1995 and 2003.

NASA's Juno spacecraft, which has been orbiting Jupiter since 2016, has been taking increasingly close photos of Io over 2023 and 2024, documenting the stark changes all over the moon's surface since Galileo's flybys. Juno has also been examining the north and south of the moon more closely, which Galileo couldn't see in much detail when it took photos in 1997.

One of the most significant changes is the appearance of a new volcano near a region of active lava flows, called Kanehekili Fluctus, in the moon's south-west.

The volcano, spotted by Michael Ravine at space company Malin Space Science Systems and his colleagues, was visible in a photo taken on 3 February. "We observed surface changes in many, many different locations, on timescales of years and even months," Ravine told the Europlanet Science Congress in Berlin on 9 September.

There appear to be two active streams of lava coming from the volcano, each running for about 100 kilometres, on its western side,

"There are two active lava streams and a 60 by 90-kilometre deposit of red sulphur"

as well as a deposit of red sulphur, covering a 60 by 90-kilometre area to its east. The findings provide further evidence of just how volcanically active Io is.

Some changes to Io's surface also occurred between flybys separated by just a few months. A striking 1000-kilometre-wide red ring surrounding a volcanic crater in the south-west of the moon, called Nusku Patera, appeared between Juno's 3 February and 9 April flybys. This is likely to be caused by sulphur deposits from a volcanic plume, said Ravine. ▮

Alex Wilkins

New Scientist Live
Volcanoes and past climate
Hear Tamsin Mather's insights about a warming world on 12 October **newscientist.com/nslmag**

Zoology

Ants alter their nests to stop disease spreading

Michael Le Page

WHEN ants are exposed to a pathogen, they change their nests to cut the risk of an epidemic.

Nathalie Stroeymeyt at the University of Bristol, UK, and her colleagues put groups of 180 black garden ants (*Lasius niger*), along with larvae and pupae, in containers of soil. Cameras recorded surface activity and CT scans revealed the shape of the nests the ants dug.

After one day, another 20 workers were added to each group. These 20 workers were sprayed either with spores from a disease-causing fungus, or with the same solution without any spores.

Over the next six days, the team found that the nests excavated by the groups whose extra workers were exposed to fungal spores were more compartmentalised and less densely connected. The workers of these groups dug faster, made more tunnels and created entrances that were further apart than in the nests of ants that weren't exposed (bioRxiv, doi.org/nhbh).

The ants also placed chambers in less central positions within nests. The team's computer simulations suggest that by reducing how often ants come into contact with each other, the architecture changes cut each ant's chance of contracting a deadly infection by 10 per cent.

Black garden ants take steps to prevent infections

LIAM MARSH/ALAMY

This is a great adaptation against disease, says Erik Frank at the University of Würzburg in Germany, who has shown that ants amputate limbs to prevent infection. ▮

Climate science

Giant El Niños may have amplified Earth's biggest mass extinction

THE Great Dying at the end of the Permian Period 250 million years ago may have been amplified by El Niño events far stronger and longer lasting than any today.

These mega El Niños caused climate swings that killed off forests and many land animals, says Alexander Farnsworth at the University of Bristol, UK. They also triggered feedback processes that helped make this mass extinction worse, he says.

About 90 per cent of all species at the time may have died out during the end-Permian extinction, making it the worst ever mass extinction. It is widely thought to have been triggered by massive volcanic eruptions in what is now Siberia.

These released huge quantities of carbon dioxide that led to extreme global warming. The ocean became stagnant and low in oxygen, killing off marine creatures.

But this doesn't explain everything. In particular, land species started going extinct tens of thousands of years before those in the sea. Many ideas have been put forward to explain this, from volcanic winters to the loss of the ozone layer. The idea that extreme El Niños might be involved emerged from studies of past ocean temperatures, based on oxygen isotopes in fossils.

Now, Farnsworth and his colleagues have run computer models to explore what might have happened at the end of the Permian that could explain the fossil findings.

Today, El Niño occurs when warm water in the western Pacific spreads east across the surface of the ocean. This creates an area of abnormally warm water that heats the atmosphere and affects weather across the planet.

RICHARD JONES/SCIENCE PHOTO LIBRARY

High temperatures may have killed forests in the end-Permian extinction

Before the Permian extinction began, the researchers found, El Niños were probably of a similar intensity and duration as today. That is, the anomalously warm water was about 0.5°C (0.9°F) hotter than average and the events lasted for a few months.

These events, however, were happening in a massive ocean called Panthalassa, which was 30 per cent wider at the equator than the Pacific Ocean is today. This means the area of anomalously warm water in El Niños was much larger than today, and had a bigger impact.

As CO_2 levels rose at the end of the Permian, these El Niño events got stronger and longer, the team's models suggest. They caused extreme swings in the weather on land that killed off forests, which stopped soaking up CO_2 and started releasing it, leading to more warming and even more extreme El Niños (*Science*, doi.org/nhhx).

In the sea, the temperature variations would have been less severe, which explains why marine extinctions happened later, when global warming got more intense.

By the peak of the extinction, the temperature anomaly during El Niños was up to 4°C (7.2°F), with each event lasting more than a decade, he says.

It isn't clear if something similar will happen in the future. Computer models vary in their forecasts of how El Niños will change as the planet warms, says Farnsworth. But they are already having a bigger impact because they are happening in a warmer world.

"The El Niño we just had was helping set record temperatures everywhere and leading to a huge amount of forest fires," he says. "And the thing that disturbs me most is tentative signs during this El Niño of dieback in the Amazon."

"I think it's a compelling study," says Phil Jardine at the University of Münster in Germany. "The deadly thing about the end-Permian mass extinction seems to be that a lot of things were happening at once, and interacting with each other as they cascaded through the Earth system." ▮ **MLP**

Health

Blood test could diagnose chronic fatigue syndrome

Carissa Wong

CHRONIC fatigue syndrome (CFS) could one day be detected via a blood test, thanks to the discovery of 116 biomarkers that seem to occur in people with the condition.

Also known as myalgic encephalomyelitis (ME), CFS commonly causes extreme fatigue, sleep problems and brain fog, with symptoms worsening after exercise or mental activity.

The cause of CFS is unknown. Doctors diagnose it by ruling out other conditions that cause similar symptoms, such as anaemia, an underactive thyroid gland or problems with the liver or kidneys. But many cases are missed or take years to identify. "It's a complicated disease and there's no test," says Chris Ponting at the University of Edinburgh, UK.

Now, Ponting and his colleagues have analysed blood samples collected from more than 132,000 people as part of the UK Biobank study, of whom 1455 had been diagnosed with CFS.

After taking into account other factors that could influence results, such as the participants' ages and levels of physical activity, the researchers identified 116 markers that differed between people with CFS and those without it, including levels of certain blood cells, fatty molecules and proteins (medRxiv, doi.org/ng83).

These markers are involved in processes such as inflammation, blood sugar control and liver disease, says Ponting. It isn't known whether the changes to these markers occur before or after someone develops CFS, he says.

"It is vital to get biomarkers for ME," says Douglas Kell at the University of Liverpool, UK. Besides helping with diagnoses, studying these markers could also give insights into what is causing an individual's CFS, which may aid treatment, he says. ▮

Archaeology

Genome from fossil teeth reveals lost Neanderthal group

Alison George

XAVIER MUTH

LUDOVIC SLIMAK

The jawbone of Thorin the Neanderthal (left) was uncovered in Grotte Mandrin, France (above)

GENETIC analysis of a Neanderthal fossil reveals it was from a previously unknown lineage, a remnant of an ancient population that was isolated for more than 50,000 years. The finding sheds new light on the end of the Neanderthals.

The fossil, dubbed Thorin after a character in J. R. R. Tolkien's *The Hobbit*, was discovered in 2015 at the Grotte Mandrin in the Rhône valley in France when Ludovic Slimak at the Centre for Anthropobiology and Genomics of Toulouse uncovered some teeth in the cave. The skeleton was excavated over nine years to reveal 31 teeth, the jawbone, part of the skull and thousands of other bone fragments.

This was an incredible discovery because remains of Neanderthals – who lived in Eurasia from around 400,000 until 40,000 years ago when they went extinct – are very rare.

Even more surprising was that Thorin's genome could be obtained from a fragment of one of his teeth, as DNA isn't typically preserved in warm climates. This revealed that the fossil was from a male, but opened up another mystery.

After comparing his genome with those of other Neanderthals, Slimak and his colleagues estimated that Thorin lived some 105,000 years ago. However, archaeological evidence and analysis of the isotopes in his bones showed that Thorin lived no more than 50,000 years ago – making him a "late Neanderthal" from the final phase of the species' existence.

"For a very long time we [geneticists] were convinced that Thorin really was an early Neanderthal, just because his genetic lineage was so distantly related to contemporary Neanderthals in the same region," says team member Tharsika Vimala at the University of Copenhagen, Denmark. "The archaeologists were convinced that he was a late Neanderthal."

Eventually, the researchers realised they must have discovered a hitherto unknown lineage. Thorin was part of a group that lived between 42,000 and 50,000 years ago. It seems to have been a remnant of a more ancient Neanderthal population that diverged from the main population some 105,000 years ago, and had then stayed genetically isolated for more than 50,000 years (*Cell Genomics*, doi.org/ng8x).

Thorin's DNA showed no sign of interbreeding between his lineage and that of the main Neanderthal population. "Thorin was completely divergent from any other Neanderthals," says Slimak.

Further genomic evidence from another Neanderthal who lived some 43,000 years ago at Les Cottés, France, revealed there were probably three distinct populations among late Neanderthals, says Slimak.

"The evidence from Grotte Mandrin is fascinating as it gives some intriguing insights into these late Neanderthal populations," says Emma Pomeroy at the University of Cambridge. ▮

New Scientist Live

How our biology shaped history

See Lewis Dartnell discuss the course humans have taken on 13 October newscientist.com/nslmag

Quantum physics

Chemistry law needs quantum update

An equation describing chemical reaction rates seems to require tweaking for the quantum realm

Karmela Padavic-Callaghan

A 135-year-old chemistry law is getting a quantum makeover. An experiment with a single quantum bit, or a qubit, has uncovered that the Arrhenius equation, which describes how reaction rates change with temperature, must be modified to apply in the quantum realm.

Rodrigo Cortiñas at Yale University says he never doubted that the Arrhenius equation, first proposed in 1889 by Swedish chemist Svante Arrhenius, would translate directly to a quantum experiment – until he and his colleagues found otherwise. "This was really an accident," he says.

The researchers constructed a qubit – the basic building block of quantum computers – from a small superconducting circuit, which they could control with microwaves.

Next, Cortiñas and his colleagues made the current in the circuit oscillate within a so-called potential energy well, a state it can't get out of unless extra energy is added to the system. It is a bit like a cherry tomato rolling back and forth at the bottom of a deep salad bowl, except that in their setup, there were two potential wells.

1889

year the original version of the Arrhenius equation was proposed

Because of the quantum phenomenon of tunnelling, in which quantum objects can breach normally impassable energy barriers, disturbances in the system could make the qubit unexpectedly move from one of the wells to the next.

Team member Nick Frattini at Nord Quantique in Canada says the team wanted to learn how to stop this, and the Arrhenius equation should have been helpful.

According to this law, increasing the energy difference between the two wells should exponentially decrease how often the qubit tunnels between them. This means that plotting this energy difference alongside the rate of tunnelling should produce a smooth curve. Instead, the researchers' data showed a jagged line resembling a staircase.

Eventually, they realised they were seeing a consequence of the fundamental quantum constraints on which energies the qubit could have. In the macroscopic world, the Arrhenius equation assumes that any energy level is permitted, but quantum theory only allows a set of special values – a ladder of discrete energy levels. For quantum objects like a qubit, Arrhenius's law must reflect this structure.

So, each step in the researchers' data corresponded to a specific qubit energy level (*Physical Review X*, doi.org/ng6x). Cortiñas says it is technically difficult to experiment with a qubit that can be at any rung of the energy ladder, and experiments typically only explore the first two, which has prevented the full effect from showing up in previous work.

Jonathan Friedman at Amherst College in Massachusetts studied a similar stepwise behaviour in how particles change their quantum states in magnets. He says that using the conventional, smooth version of the Arrhenius equation in systems susceptible to quantum effects can lead to large errors.

With objects like magnets, superconductors and qubits, you may expect that you can create a big change in their quantum states by making a small change – such as in temperature or magnetic field – but if you hit a step on the Arrhenius staircase, next to no change will actually occur, he says.

The accidental discovery also helped Cortiñas and Frattini improve their qubit. They can now make it stay in one well for 10 times as long as it would before, a kind of reliability that is necessary before it can be connected to other qubits to make a working quantum computer. ▮

Zoology

Fish size themselves up in a mirror before getting into a fight

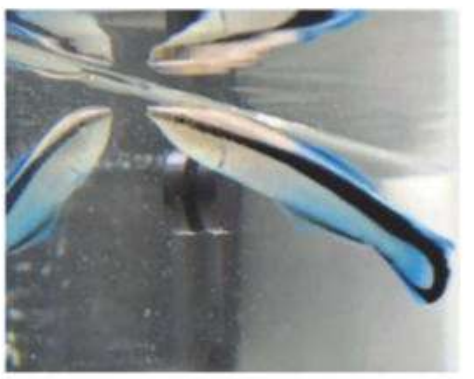
BEFORE deciding whether to fight another fish, some cleaner wrasse seem to check out their own reflection in a mirror and see how they measure up to the opposition.

Bluestreak cleaner wrasse (*Labroides dimidiatus*) are remarkably smart. These finger-sized coral reef fish were the first fish to pass the mirror test, a common assessment to see if an animal recognises that the reflection is of its own body and not another animal.

Taiga Kobayashi at Osaka Metropolitan University in Japan and his colleagues have now found that these wrasse use their likeness to construct a mental image of their body size, which they can compare with others.

First, the researchers tested the fish's willingness to go on the attack. Against the glass wall of the fish tank, they held up an image of another wrasse that was either 10 per cent larger or smaller than the real fish. Regardless of the size of the model fish in the photograph, the territorial wrasse picked a fight.

Then, they repeated the test but added a mirror, and the fish checked out their reflection. But when the researchers held up a photo of a larger or smaller cleaner wrasse to the glass pane, the fish chose to fight only smaller rivals (*Scientific Reports*, doi.org/ng66).



OSAKA METROPOLITAN UNIVERSITY

A bluestreak cleaner wrasse checking out its own reflection

"This was unexpected because we had an image that this fish always shows aggression against rivals, regardless of size," says Kobayashi.

The tank was partitioned so that the wrasse couldn't see its reflection and the rival fish's photo at the same time – so scientists think the fish must be comparing the image to a mental approximation of their own body size.

Cleaner wrasse evolved in an environment without mirrors, so how did they end up with this skill? Whether in the lab or in the wild, it benefits a fish to know what size they are before picking a fight, says Kobayashi. In other words, the fish were clever enough to employ the mirror as a decision-making tool. ▮

Corryn Wetzel

Events

NewScientist

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More speakers to be announced shortly.

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Comment

Look to the future

A new Declaration on Future Generations could be as transformational as 1948's Universal Declaration of Human Rights, says **Thomas Hale**

SCIENTISTS who study the climate work with data that goes back thousands of years and build models that project centuries into the future. Meanwhile, CEOs and politicians base their decisions on business, political and news cycles. Can we reconcile this gap? A new gathering is going to try.

This week, world leaders will arrive in New York for the UN Summit of the Future, one of the most ambitious international conferences ever convened. It aims to cover everything from war to the economy, climate change to artificial intelligence.

Present and future generations need exactly this kind of ambition. But in the face of fierce rivalry and broken trust between nations, and on the eve of a pivotal US election, world leaders will certainly fail to agree a major breakthrough. However, among the high-level outcomes of the summit is a seed of potentially radical transformation: a "Declaration on Future Generations", which would commit countries to safeguarding the needs and interests of future citizens.

Why do the interests of generations to come matter? Scholars are increasingly focused on governance tools that help overcome the temporal gap between the problems we face and the decision-making systems we use. It is clear that giving future generations a voice and ensuring that politicians listen can, under certain conditions, move the dial on some of the long-term issues facing our societies, like climate change and ageing populations.

SIMONE ROTELLA

We need new tools because our political systems were never designed to solve these "long problems", which span nations and generations. For example, with an issue like climate change, leaders need to act to prevent it well before its effects have fully been felt. In the meantime, politicians also have a pile of short-term crises on their to-do lists. But this means long problems have been left to fester and grow. The only solution is to get ahead of them.

It gives me hope that this is already happening in some places around the world. Countries from Finland to Kenya already have parliamentary committees for the future that examine legislation in terms of how it could affect future citizens. These tools can make a political difference. In August, for example, the South Korean constitutional court became the latest tribunal to order its government to establish stronger long-term climate targets to protect future generations.

Momentum is building. Wales broke ground in 2015 as the first country to establish an independent commissioner for future generations, tasked with scrutinising government decisions for future effects on the well-being of the Welsh people. One of the key accomplishments of this policy has been the creation of a longer-term healthcare strategy for Wales that emphasises prevention, saving lives and money. This year, the European Union will become the largest jurisdiction to appoint a similar role.

The radical potential of the Declaration on Future Generations is to muster these piecemeal reforms into a major revolution towards more long-term policy-making across the globe. The UN has catalysed these kinds of transformations in the past – just look at the Universal Declaration of Human Rights in 1948, which helped turn a loose set of moral principles into a robust system of law around the world.

It would be difficult to argue that the geopolitical landscape is more fraught than it was in 1948, when the cold war was beginning. Could this new declaration seed a similar transformation to address long problems?

That depends on what governments and societies do next. But the long view teaches us that big transformations often grow from ideas that, once stated and agreed upon, can't be denied.

Thomas Hale is at the Blavatnik School of Government, UK. He is the author of *Long Problems*

Field notes from space-time

Atomic physics for beginners

A recent workshop was outside my comfort zone, but we physicists could learn a lot by stepping beyond our specialisms, says **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her most recent book is *The Disordered Cosmos: A journey into dark matter, spacetime, and dreams deferred*

Chanda's week

What I'm reading
Readers who are curious about atomic physics should check out Felix Flicker's The Magick of Physics: Uncovering the fantastical phenomena of everyday life.

What I'm watching
Right now, I'm completely obsessed with the TV show Snowpiercer.

What I'm working on
Sadly, I spent part of my Australia trip working on a grant.

This column appears monthly. Up next week: Graham Lawton

A CENTURY ago, it was possible for a physicist to know almost everything there was to know about physics. Now, this is far from the case. It isn't that the physicists of today are less competent. The problem is that humans simply know so much about the inner workings of the universe that it is impossible for someone to be deeply familiar with all of it. As a result, today's tendency is to produce specialists.

For example, I trained initially as a relativist: general relativity and quantum extensions of it, applied to cosmology, were my specialist areas of physics. Eventually, I shifted to working in particle cosmology, connecting particle physics with fundamental questions about the history of space-time. When it comes to research, I have done nothing else for 22 years.

As a PhD advisor, I understand the need for budding scientists to focus on developing expertise in a specialist subject. But this can represent a problem down the line. When we continue to use the same tools and ideas over and over again, there is a risk that we stop thinking outside the proverbial box. And there is no expectation that professional physicists will do any kind of continuing education to maintain their general knowledge or develop familiarity with other areas.

The last time I did research outside the area of cosmology was the summer I spent building lasers in an atomic physics lab. I ended up in the role after performing highly in my second quantum mechanics class, taught by Lene Hau (the only woman professor I ever had as a student). In that class, we learned that certain types of particles, bosons, could collapse into a single state where they behave collectively like one superparticle. This condition of matter is called a Bose-Einstein condensate (BEC), and while I was at university, three of the scientists who led the labs where the first BECs were formed won the Nobel prize. I was hooked and asked Professor Hau for a job in the lab where she was doing related research.

Though I eventually chose to stick with cosmology, I never lost my adoration for atomic physics. This paid off when I stumbled into the area of research I am best known for: BEC dark matter, dark matter that can form these superparticle states. I pursued

"Attending a meeting where people were talking science far afield from what I do was an intellectual challenge"

the project specifically because it allowed me to draw on atomic physics and particle cosmology at the same time.

This work has taken me many places, figuratively and literally. Not only did it put me on the path to professorship and tenure, but at the end of August, it took me to Australia. The trip was one of firsts: my first time to Australia and my first time at a workshop focused on atomic physics. Part of working on BEC dark matter involves translating ideas from atomic physics, and in the process I had spent years trying to understand the work of Matthew Davis at the University of Queensland. When Davis reached out to me because he had read my book, I had a fangirl moment via email and we jumped on Zoom to talk science. A year later, he invited me to give a workshop lecture.

Attending a meeting where people were talking science that is far afield from what I do was an intellectual challenge. I took notes on every talk, and frequently those notes were just lists of words and concepts that I would need to look up later. It was a good reminder of what it's like to be a beginner.

A lesson I learned at FINESS 2024 – Finite Temperature Non-Equilibrium Superfluid Systems – is that my understanding of what physicists do has been too narrow. I thought particle physicists, cosmologists, quantum gravity theorists and astrophysicists had cornered the market on asking esoteric fundamental questions about the basic nature of the universe. Atomic physicists worried more about practical matters, right? But at FINESS, what I witnessed was a community that was putting quantum matter in a variety of different conditions in the lab, just to see what happened. People were trying atomic physics calculations, just to see what came out. They were exploring the fundamental nature of matter, at different scales than I am used to.

The workshop was a dream, really. My entire career I have wanted to be in rooms where people are focused on curiosity, where people cheer each other on (every question began with a compliment about the talk) and where there are lots of unresolved scientific questions. FINESS was my first real experience with that – 25 years after I began university. Besides gathering a few ideas to try out in my dark matter research, I also came away with a new perspective on why physics remains a vibrant area of research.

I also found myself wondering: what if physicists had time to do occasional intensive continuing education where we learn about science well beyond our own? The results could be amazing. ▮

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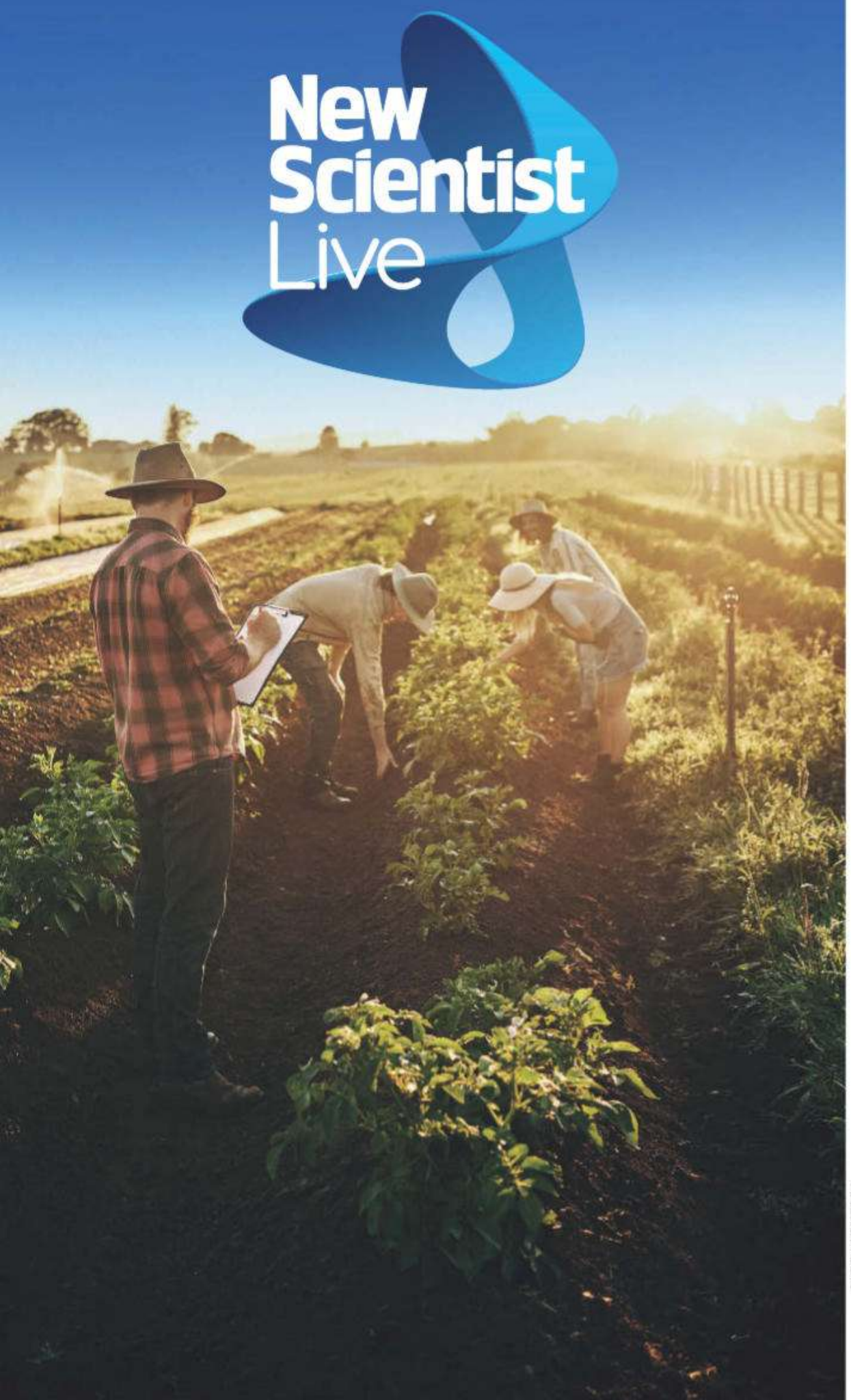

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ADVERTORIAL

Farming with nature: the promise of agroecology

Agroecology is more than just a buzzword; it's a radical rethink of how we grow our food. This approach to farming marries agriculture with ecology, aiming to create systems that are both productive and sustainable.

"Agroecology is about understanding and supporting the relationships between soil, plant, animal and human." says Dr Jonathan Code, Senior Lecturer in Sustainable Land Management at the Royal Agricultural University.

"As much as we've tried to increase yield in agricultural environments," Code adds "Have we also been able to do that while maintaining good soil, health? Have we been able to support bees, butterflies, pollinators, birds and, essentially, biodiversity in its broadest sense?"

Unlike conventional agriculture, which often relies heavily on chemical inputs, agroecology seeks to align with natural processes. This can involve practices like crop rotation, intercropping, and agroforestry – planting trees among crops. By diversifying the landscape, farmers can enhance soil health, reduce pest and disease pressures, and create habitats for wildlife.

Jonathan likes to think of there being three 'legs' to the 'stool' of agroecology. The first two are agriculture and ecology. "But for me, there's a 3rd leg, and the 3rd leg really is people."

"With the rise of farmers markets, and interest in buying from the producer, we could say, is already within an agroecological space."

While agroecology offers immense potential, it's important to note that transitioning to these systems can be challenging. Farmers may need access to new skills, markets, and financial support. However, the long-term benefits for both people and the planet make it a compelling vision for the future of food.

You can find out more by visiting the Future of Food and Agriculture stand at New Scientist Live 2024. For more details go to: live.newscientist.com

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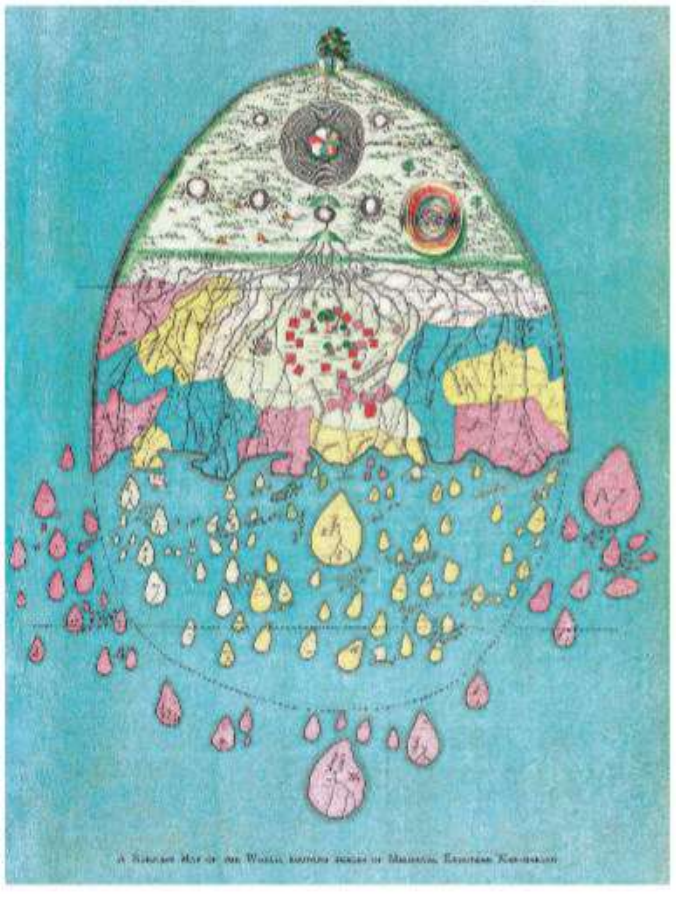

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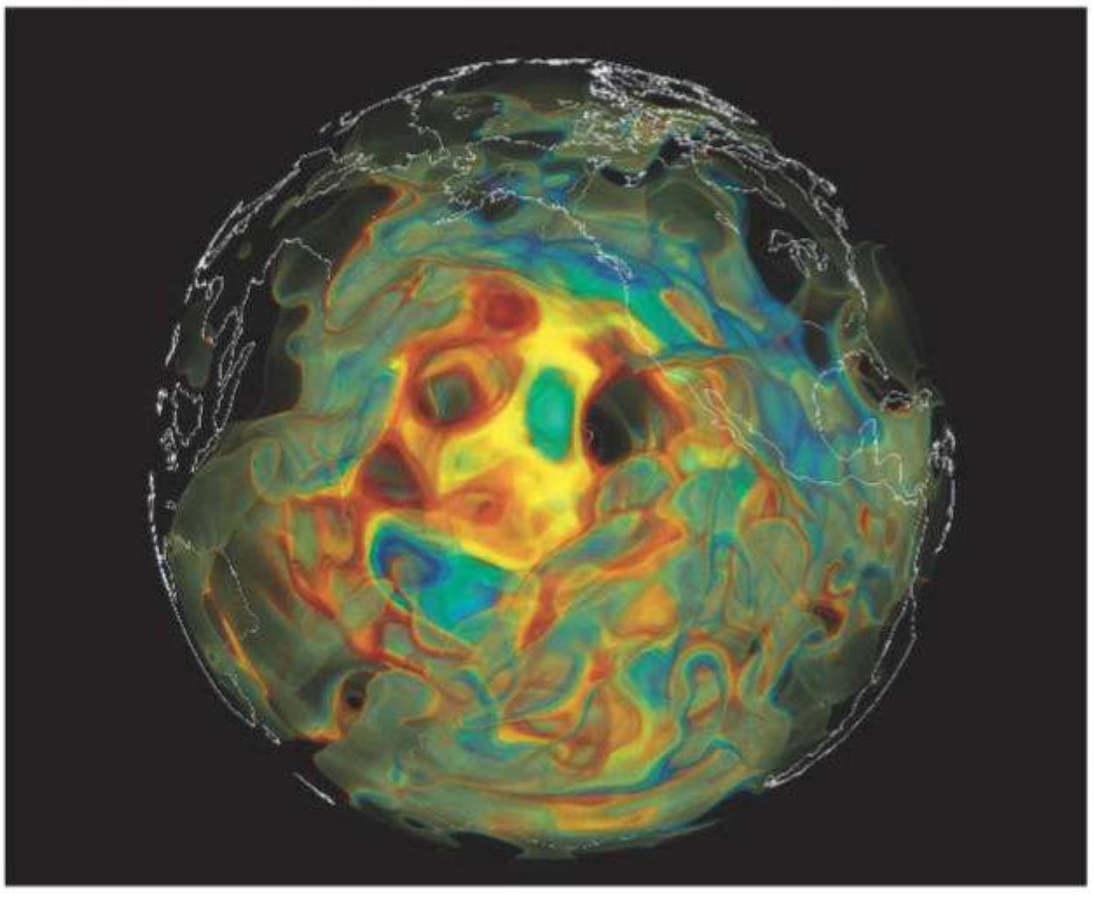

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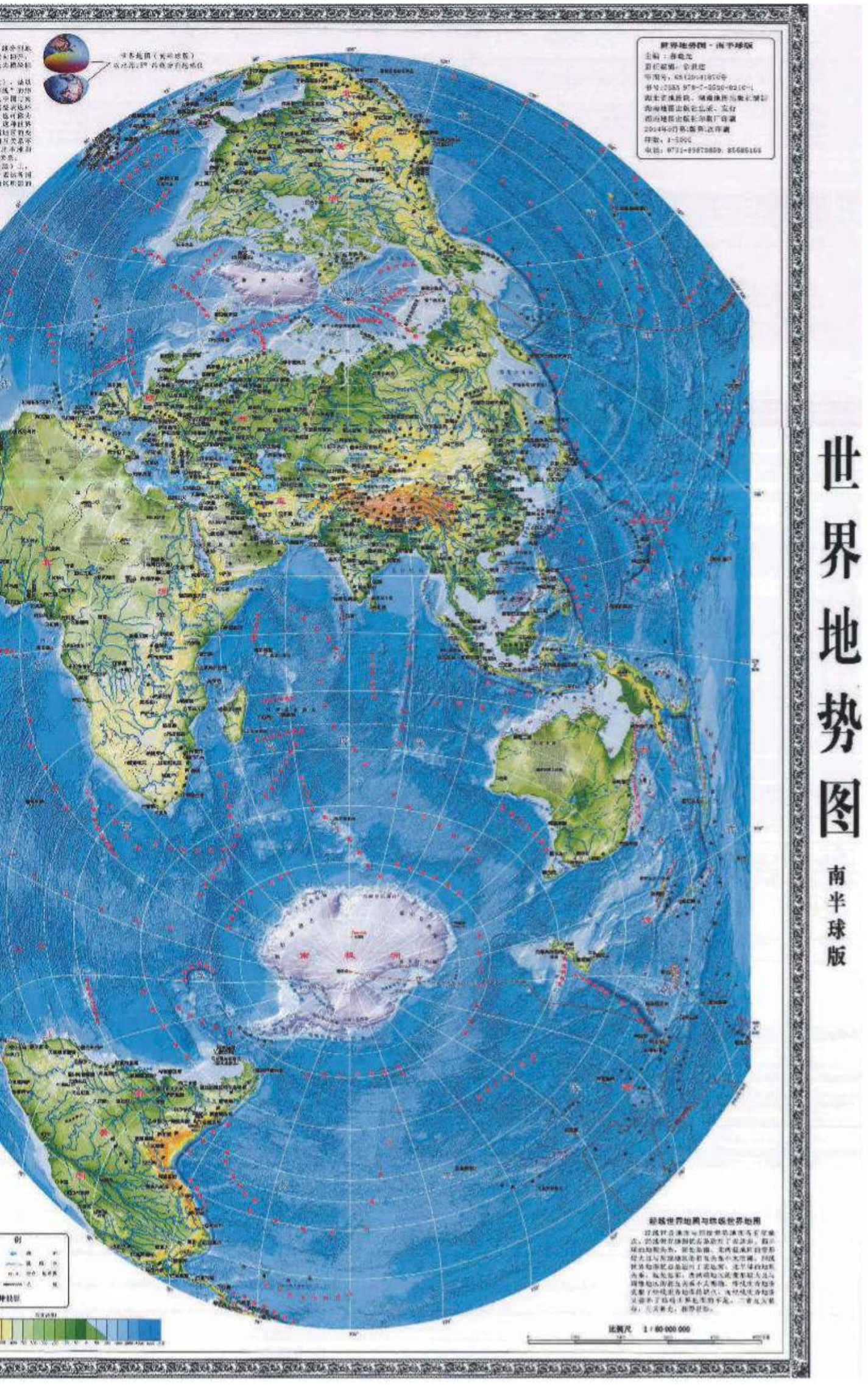
Off the charts



Author **Alastair Bonnett**
Publisher **Ivy Press**

MAPS are ubiquitous today, used for everything from tracking the spread of disease to finding where to get your groceries. But despite this state of affairs, geographer Alastair Bonnett is concerned we don't always know what makes for a good map, or how people have used them over the centuries. "We need to... think about the lost traditions of cartography," he says.

In his new book *40 Maps That Will Change How You See the World* (out 26 September), Bonnett does just that, putting together a tour of diverse cartographic traditions. These range from a Chinese map from 2013 (near-left), in which a vertical depiction puts Asia at the world's centre, to a 1593 example (shown in part, top, far-left), in which Aztec leader Lord-11 Quetzalcatzin (in red) asserts land rights over what are now Mexico's Puebla and Oaxaca regions. This, says Bonnett, is "one of the most important maps in the history of the Americas" because it captures a cultural transition between Indigenous and postcolonial societies, with elements of the cartographic traditions of both.

The "Burmese Map of the World" (bottom, far-left) takes a different view. Reproduced in 1906 from a chart of unknown origin, it depicts the Himalayas refracted through a Buddhist cosmology.

Maps can extend below the surface too. The final one (bottom-middle) reveals the structure of the mantle below the Pacific Ocean based on reflected seismic waves in the region. Produced in 2015, it portrays the speed of the waves as they move through different materials at different pressures and temperatures. The slowest speeds are in red and orange, the fastest in green and blue.

James Dinneen

Editor's pick

Are we here to solve a wicked problem?

Letters, 7 September

From Rob Walter, Canberra, Australia

Living in a simulation wouldn't get rid of the need to solve climate change – in fact, it may amplify it. If reality is a simulation, then it must have been created for some purpose. Since the most common use of simulations is research, it is possible we have been created to answer some question.

I think the most plausible reason to simulate a universe is to find the answer to some wicked, existential problem that the simulators have been unable to solve in any other way. If so, then our duty to our creators, and to each other, is to overcome the challenges our society faces to provide the best answers to whatever the unknown question behind our existence may be.

Call off Artemis and give cash to Chanda instead

24 August, p 20

From John Butcher, Sunbury-on-Thames, Surrey, UK

Sending humans into space is a total waste of time and money. What should we do with the funds instead? Give some to columnist Chanda Prescod-Weinstein to keep the Chandra X-ray Observatory running. The rest can be spent on many more scientific instruments that need funding.

Using maths to drive even more efficiently

7 September, p 17

From Eric Kvaalen, Les Essarts-le-Roi, France

Research shows we shouldn't slam on the brakes at a red light, but rather start slowing down before, in order to cut emissions. But it depends. When I come around a corner and see a red light ahead of me and no cars between me and it, I don't brake – I push the clutch and glide, hoping the light will turn before I get there. If it doesn't, then of course I have to brake. That minimises the expected consumption of fuel.

If there are other cars waiting at the red light, then I slow down in such a way that when the light turns green I can continue driving without having to brake anymore. (I have a bag of such tricks I have worked out mathematically, and use!) The same things can be done in an electric vehicle as in an internal combustion vehicle. We want to save energy, whether from fossil fuel or from renewable resources!

What makes us human? Our self-delusions

3 August, p 32

From Chas Bazeley, Colchester, Essex, UK

The more I learn in *New Scientist* about the physical, mental and emotional abilities of animals, the more it strikes me that the only thing that makes us distinctly human is our almost limitless capacity for self-delusion

The blob can play, but can it actually think?

31 August, p 13

From John Cantellow, Derby, UK

You report that a blob of jelly can play the game *Pong* thanks to a basic memory. To me, this implies some form of synthetic cognition, especially since the polymer used utilises ion transport, the same "technology" employed throughout the human body, including the brain.

This and similar experiments raise the question: "What constitutes cognition?" The jelly achieved the objective of showing basic memory. However, human cognition was involved in both the inputs to the blob and subsequent processing of the output, which was crucial to positioning the pong paddle.

If a human could only fly a plane based on an instructor's continual prompts, I would say they haven't demonstrated the ability to fly the plane. Clearly, some human involvement will be needed in setting up such experiments, but at what point does that detract from a claim of material cognition?

Taking the scenic route: IKEA got there first

Letters, 17 August

From Brian Reffin Smith, Berlin, Germany

A reader's suggestion of encouraging healthy mobility in an office by designing a necessity for longer walks seems innovative, but surely stores such as IKEA have been doing this for decades. However, the health gain of being shunted past acres of bedding and lighting to get to a dinner plate might be negated by the stress and irritation due to following the cynical, maze-like layout.

Unimpressed by the new wave of AI chatbots

Letters, 31 August

From Richard Prior, Beaworthy, Devon, UK

I applaud Michael Crowe for calling out "so-called AI". Maybe I am not alone after all in finding the current crop of AI assistants like a pack of over-eager office boys getting under my feet and clamouring to tie my shoelaces.

Ironically, I find myself torn between the temptation to shout at them to "go and find something useful to do!" and guiltily feeling I have some responsibility for helping them to grow up. Given that all our interactions are being closely scrutinised by their AI masters for their own purposes, would they grow up more quickly if I did shout at them?

Worrying unknowns in mental health crisis

24 August, p 14

From Stephanie Woodcock, Carnon Downs, Cornwall, UK

Many possible factors are outlined that might lie behind a seemingly unstoppable rise in poor mental health among young people. Issues around climate change, lockdowns, smartphones and social media are all suggested as possible causes. Greater awareness and openness around mental health could also contribute.

Worryingly, there is no real proof that any of these are causal. And if none of these account for the rise, then what does?

Realism seems unlikely in quantum mechanics

7 September, p 32

From Nick Canning, Coleraine, County Londonderry, UK

Evidence seems to contradict the proposed realistic interpretation of quantum mechanics.

That evidence is Nobel laureate Anton Zeilinger's "entanglement transfer" experiment. It involves two entangled pairs of photons. The polarisation of one of each pair is separately measured. Only much later, after either passing through a device that entangles the two remaining photons, or not, are the other photons measured. The meaning of the correlations of the first photon measurements alters depending on the presence or absence of the entangling device prior to the later measurements.

The results imply that all talk of pre-existing reality of the photon polarisations before all irreversible measurements are completed is meaningless, a fatal blow to the realistic interpretation reported.

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Getting to grips with uncertainty
See David Spiegelhalter speak at New Scientist Live on 12 October **newscientist.com/nslmag**

Knowing the odds

How do we deal with a world where uncertainty is inevitable? A thought-provoking guide helps us to think about it, says **Alexandra Thompson**

MARTIN PARR/MAGNUM PHOTOS

You may seek to beat the slots, but that's down to luck's complexities

Book

The Art of Uncertainty
David Spiegelhalter
Pelican (UK, out now); W. W. Norton (US, 4 March 2025)

I AM not a twin, but I share a birthday with my sister, who is three years older than me. When I tell people, I normally get one of two reactions: either a lewd joke about how nine months earlier must have been a special date for our parents, or a "what are the chances?"

In my ignorance, I have always assumed it was simply 1 in 365. And in his new book *The Art of Uncertainty: How to navigate chance, ignorance, risk and luck*, statistician David Spiegelhalter explains why I am correct: 1 in 365 is the chance of any individual being born on a particular day of the year, but the chance that a pair of non-twin siblings would share a birthday is still 1 in 365.

The Art of Uncertainty follows on from Spiegelhalter's bestseller *The Art of Statistics*. An emeritus professor of statistics at the University of Cambridge, he was on hand during the covid-19 crisis to help us think through what the statistics can and can't tell us. Spiegelhalter has spent his career crunching numbers to learn from past events and assess what may happen in the future. With this thought-provoking new book, he aims to give readers a window into how they can apply this in their own lives.

A book on statistics will inevitably be number-heavy and full of terms not generally seen outside a classroom, such as "Bayes's theorem" and "Poisson distribution". Spiegelhalter warns readers early on that his book will be complex at times, but the nature of the subject makes this unavoidable. He does as well as he probably can at explaining statistical words and phrases in familiar terms, providing a glossary at the back of the book and a summary box at the end of each chapter for a snapshot of the points he has covered.

By digging into the data, Spiegelhalter manages to set straight some of life's everyday uncertainties. For instance, could eating burnt toast really give you cancer? Well, if you were to eat an enormous 160 slices a day, you would still only be putting yourself at low risk. While this sort of information is interesting, I was most keen to learn how I could use statistics to bring about more fortuitous events in my life, preferably lottery wins.

"I was thrilled to learn that my health won't suffer too much if I mistakenly burn my toast in the morning"

It turns out that luck is a funny thing, as Spiegelhalter demonstrates by calling on a historical and personal example. He writes about how his grandfather Cecil described being "blown up" during the first world war, surely not a lucky event by anyone's definition. But it meant that afterwards, Cecil was considered unfit for front-line duties and spent the rest of the conflict away from the fighting. This, of course, may well have protected him from sustaining a more serious, or even fatal, injury.

This is a point Spiegelhalter returns to again and again. Both the degree of luck that we feel we experience and the level of risk we are willing to tolerate vary from person to person and depend on the context.

Calling on the wisdom of psychologist Richard Wiseman, Spiegelhalter believes that good luck ultimately boils down to four traits: the ability to take advantage of opportunities, having good intuition about how to act, positive expectations that spur confidence and the resilience to turn setbacks to your advantage. This is a lot less glamorous than crystals and sorcery, but it is scientifically sound.

I didn't finish *The Art of Uncertainty* with the knowledge of how to manipulate luck to effortlessly make my fortune. But I was still thrilled to learn that my health won't suffer too much if I mistakenly burn my toast in the morning.

I also now have a statistically accurate response rather than a semi-informed guess when people ask what the chance is of me and my non-twin sister sharing our birthday. Whether that will put an end to all those parent-sex jokes remains to be seen. ▮

Judgment Day, again

Terminator is back – in an anime series. But striking visuals don't make up for narrative shortcomings, finds **Josh Bell**

TV

Terminator Zero
Mattson Tomlin
Netflix

HOW many times can Judgment Day arrive and/or be averted before it loses all meaning? That question has plagued every instalment in the *Terminator* franchise later than James Cameron's brilliant first two movies. It is something that the new Netflix animated series *Terminator Zero* attempts to address – perhaps in order to justify its own existence.

Cameron has no involvement in *Terminator Zero*, which was created and written by Mattson Tomlin and animated by Japanese studio Production I.G. There is no mention of Sarah Connor or her son, John, the supposed future saviour of humanity and key to all previous *Terminator* stories. Even without the Connors, the series explores the well-worn themes that have defined the franchise, while failing to introduce compelling characters or storylines of its own.

The show begins in the far-flung future of 2022, in the familiar post-apocalyptic landscape of the war between humans and machines. Once again, the evil artificial intelligence known as Skynet plans to send a Terminator, one of its cybernetic killing machines, back in time to eliminate a human who poses a threat to its dominance. "They wouldn't be… trying it again, would they?" says an exasperated resistance fighter after discovering Skynet's plans. The resistance duly sends back its own agent to protect Skynet's target, setting up a showdown in the past.

While previous sequels have inched back the date of Cameron's planned Judgment Day, Tomlin returns it to its original designation of 29 August 1997, but the 1997 of *Terminator Zero* is clearly different from the real one. Resistance fighter Eiko (voiced in the English-language version by Sonoya Mizuno) arrives in a Tokyo where robot helpers known as Innos are common, though they are much less sophisticated than Terminators.

Eiko is there to track down and protect scientist Malcolm Lee (André Holland), who has been developing his own AI to counteract Skynet, thanks to seemingly prophetic dreams he has about Skynet's imminent destruction of humanity.

The Terminator (voiced by Timothy Olyphant) has only a few lines in this anime series

NETFLIX

Malcolm spends most of *Terminator Zero* stuck inside an augmented reality chamber communing with Kokoro (Rosario Dawson), the AI he believes is the key to salvation.

That leaves the action to Eiko as she tracks down Malcolm's three whiny, annoying children, whom the Terminator plans to use as leverage to force Malcolm to destroy Kokoro. Confusingly, Eiko also wants to destroy Kokoro, and Tomlin's additions to a convoluted franchise mythology undermine the plot's stakes rather than enhance them.

The Terminator (voiced by Timothy Olyphant), which has been the most iconic villain of the series, is truly a zero, speaking only a handful of lines throughout the episodes and lacking the presence of previous android adversaries played by Arnold Schwarzenegger, Robert Patrick and Kristanna Loken. Tomlin relies on callbacks and audience goodwill for much of the momentum, but the tone is rote rather than invigorating. "He'll be back," Eiko sighs after pushing the Terminator down an elevator shaft.

The later episodes offer bolder storytelling choices, but, as in his underwhelming 2021 feature film *Mother/Android*, Tomlin delivers a muddled take on the connection between humans and AI. The animation, from veteran anime director Masashi Kudō, is often dynamic and striking, but it can't make up for the shortcomings in narrative and character development.

Malcolm goes out of his way to negate the importance of previous time-travel efforts (sorry, to explain further is to spoil), but in the process he renders his own attempts meaningless. Whether or not this Judgment Day arrives, there will be another on the way tomorrow. ▮

Josh Bell is a writer and critic based in Las Vegas, Nevada

New Scientist *recommends*

Martin Davies
Event production head
London

As a humorous comment on the gamification of daily life, it is hard to beat this tweet from 2021: "I think Sisyphus would be much happier if they had a big number at the top of the mountain that incremented with each successful rock push, and also if they let him spend those points on fun stickers for the rock."

So, naturally, I have been playing **The Game of Sisyphus**. Based on the Greek myth of a king punished by the gods to do an eternal task, plus Albert Camus's essay *The Myth of Sisyphus*, the goal is to push a rock to the top of a hill, avoiding obstacles, only to see it roll down again.

Despite the inevitable frustration, playing felt surprisingly emotional.

I had a genuine sense of achievement after negotiating a particularly tricky ramp – a world away from the grinding emptiness of constantly levelling up in a game.

Kidreed, a reviewer on online games platform Steam, puts it well: "Did I cry because of this game? Yes. Did it feel amazing when I finished? Also yes."

STEAM

Changing times

Our increasingly indoor lives are wreaking havoc with our circadian rhythms. **Helen Thomson** explores a new guide with fresh insights and answers

L: ALEX RAMSAY/ALAMY; BELOW: FRED BAVENDAM/MINDEN PICTURES/ALAMY

Humans defy internal clocks; the little penguin (below) lives by them

Book

The Inner Clock
Lynne Peeples
Out 24 September: Bloomsbury Tonic (UK); Riverhead Books (US)

THE little penguin (*Eudyptula minor)*, a tiny, blue bird living off the coast of southern Australia, speed-wobbles from the ocean to its burrow home at the same time every day – just after sunset. Timing is crucial: too early and they miss the day's final catch; too late and encroaching darkness makes them prey for orcas and feral cats.

Fortunately for those who come to watch, environmental cues like sunlight and phases of the moon let *E. minor* keep their internal clocks tethered to the 24-hour day, ensuring a great show and giving them the best chance of survival.

Much like these penguins, we also have thousands of internal metronomes, orchestrating everything from sleep and metabolism to our ability to ward off disease. Our main pacemaker, in the brain's hypothalamus, is linked to the 24-hour day via pathways from the retina, which respond to different types of light to synchronise biological rhythms. Unfortunately, modern life is causing these rhythms to fall out of sync.

Science journalist Lynne Peeples is here to make sure we realise that this is a big problem. In *The Inner Clock: Living in sync with our circadian rhythms,* she shows how our biological timers are thrown off by everything from work patterns to environmental pollution. This wreaks havoc on our mental and physical health, she says, and we are only just beginning to fully appreciate the consequences.

We join Peeples during her vacation in a decommissioned nuclear missile complex, where she shut herself off from natural light to see how her body reacted without external cues about the time. Most of us don't need to go that far: spending too long in dim offices or staring at bright phones at night is enough to confuse our biology. A world of dark days and bright nights has sent circadian clocks straying from the sun, with consequences ranging from poor sleep and concentration to diabetes. It might even increase our risk of dementia. Circadian rhythms control the mopping up of proteins linked with Alzheimer's disease – when they falter, so does the clean-up.

> **"The Norwegian valley of Rjukan uses mirrors to reflect sunlight on residents otherwise living in shadow"**

Peeples covers a broad range of solutions. She cites the Norwegian valley of Rjukan, where computer-controlled mirrors sit atop a mountain wall flanking the town's centre. The mirrors follow the sun, reflecting rays on residents who would otherwise live in shadow.

There are simpler ways of illuminating your life, of course. Take tunable LED lighting systems, which vary in intensity so indoor light can follow the variation of natural light. A football team might use dim yellow lights in the locker room after an evening game to help them unwind, for instance.

Even painting walls white, or moving a desk near a window, will provide extra rays. It is worth it – the gain in alertness and cognition from meeting even minimum standards of 250 lux at work is remarkable, says Peeples, on par with an hour or two more sleep.

Increased understanding of the importance of biological rhythms has led to exciting applications. There are hints at potential benefits from taking vaccines at certain times of day, feeding sick babies in tune with their internal clocks and even targeting cancer more effectively at night.

Other writers have illuminated the power of light and circadian rhythms on our health – Linda Geddes's *Chasing the Sun* is a notable predecessor. But Peeples has new stories and surprises, not least in how many circadian disrupters – salt and bisphenol A (BPA), for example – have been discovered in recent years.

More on this would have been welcome, but readers need have no fear: you will still find plenty of practical tips here on how to sneak an extra "circadian snack" into your lives, reset your chronicity and live in a healthier, more timely manner. ▮

Helen Thomson is a writer based in London

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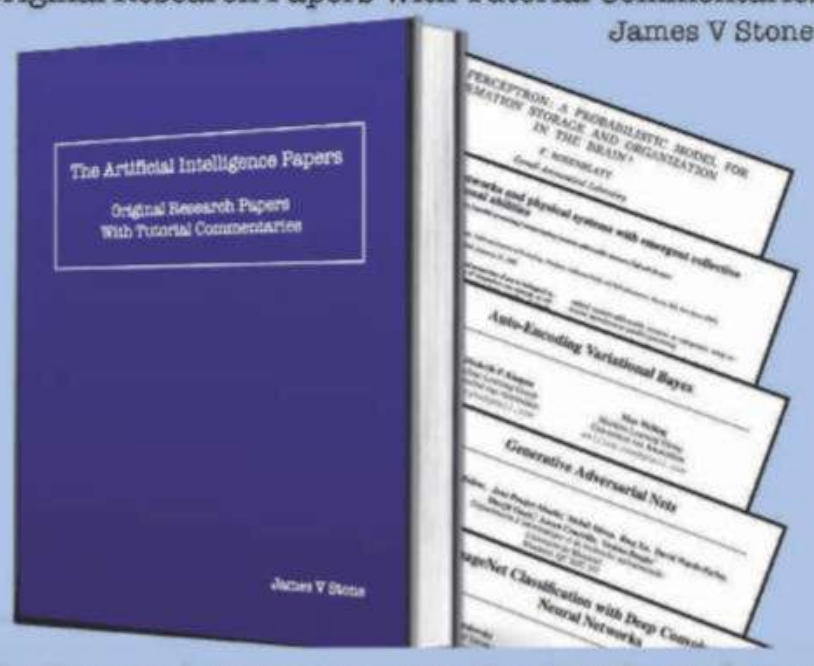

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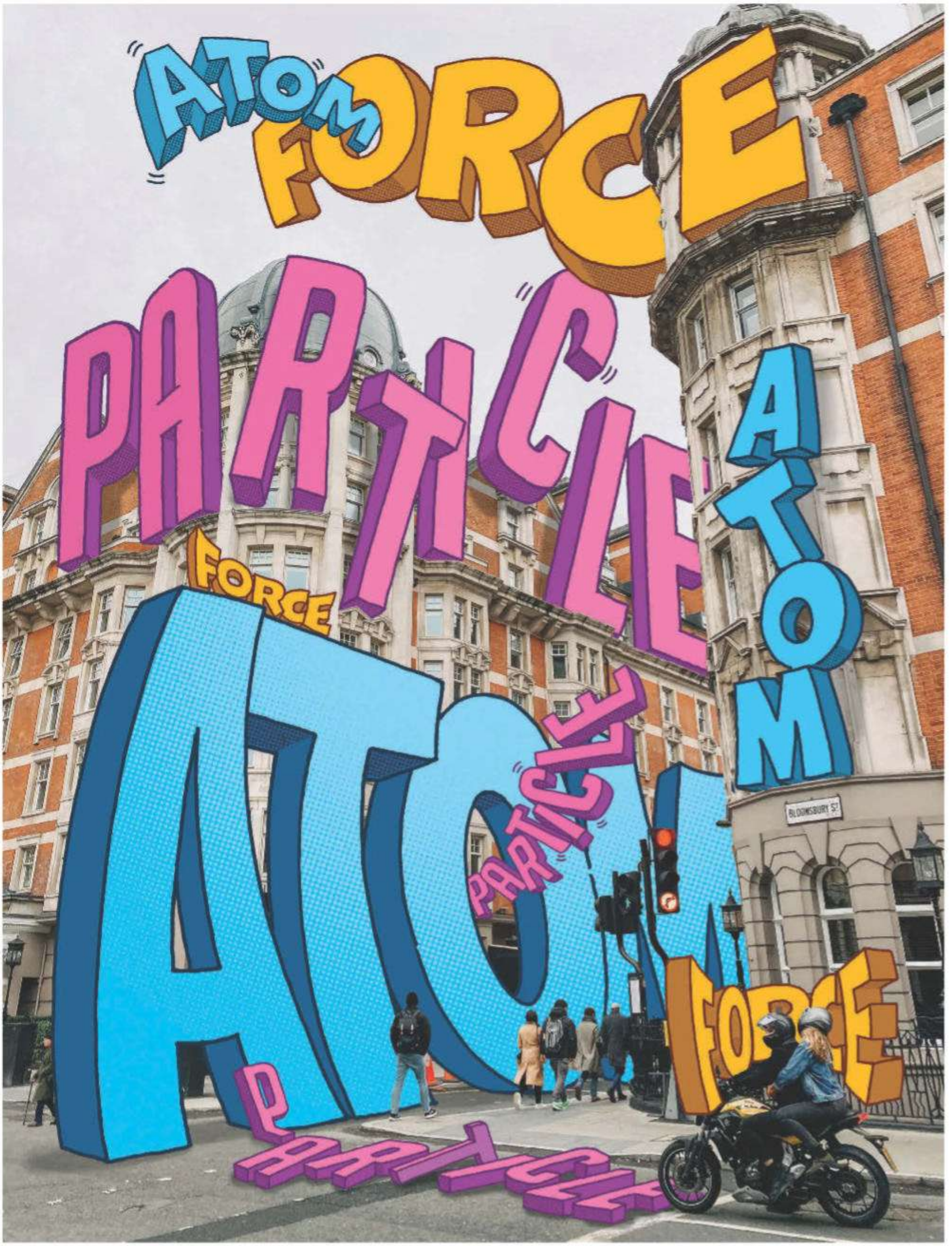
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Beyond words

The language we use to describe the basic stuff of the universe obscures the true nature of reality, says physicist **Matt Strassler**. Here's how to see things more clearly

GROWING up in the US during the oil embargo of the early 1970s, I was bombarded by public service announcements encouraging people to conserve energy. But at a very young age, I also read that "energy is always conserved", according to physics. This baffled me. If nature automatically conserves energy, why would human efforts to do so be needed?

I soon realised that physicists don't exactly speak English. They employ a dialect full of familiar-sounding terms with unfamiliar meanings (including " conserve" and "energy"). Worse still, many words, including simple ones like "force" and "mass", don't even signify what physicists originally intended. Consequently, the language we use to talk about physics obscures some of our most beautiful and fascinating discoveries about how the universe works.

Some scientists might shrug and say it is neither surprising nor problematic that the words aren't completely clear. After all, the foundations of physics are experiment and mathematics. Those are what matter; words are inevitably mere shadows.

Though I agree that data and equations are paramount, physicists convey their ideas, both to each other and to non-scientists, using language. When their wording is ambiguous or opaque, essential lessons about the cosmos may be misunderstood.

So let's look closer at the language of physics, and how three seemingly simple words have morphed over time, becoming snares for the unwary. Such deceptive terms and metaphors are widespread in physicists' dialect. In pausing to contemplate them, we can gain a clearer, deeper and more satisfying vision of reality.

Soothing the heart

To set the stage, let me begin with another short story from my youth. When I was 20, I paused my physics studies for a year to pursue music at the Paris Conservatory, taking classes in piano and composition. During my first days in the city of lights, I felt constant stress as I struggled to communicate in French. Attending a classical concert, I found it a challenge to buy a ticket, speak with the usher and decipher the programme. But when the musicians began to play, I felt a sudden rush of unanticipated relief. I had somehow forgotten that the music itself would require no translation – it would soothe my brain and heart just as it did at home.

Like music, mathematics can sometimes transcend language: the set of symbols $2 + 2 = 4$ can be wordlessly interpreted across many cultures. Since theoretical physics is the most firmly maths-based science, perhaps it inherits this linguistic independence. Must $E = mc^2$ really be translated into words?

The answer is certainly yes. E and m stand for "energy" and "mass", but what do these words really mean? No understanding of Albert Einstein's famous formula can be attained, even by physics students, without a discussion of the precise connotations of these terms. This is no small thing, because in modern physics there are multiple types of energy and mass, each with an unfamiliar definition. Unless one chooses the correct types, $E = mc^2$ isn't even true. In short, "energy" and "mass" aren't shadows, they are load-bearing supports.

With this in mind, let's dive in to the first of the three words that I want to explore in more detail. I find the history of the word "atom" particularly illustrative. Its origin is traced to the ancient Greek philosopher Leucippus and his student Democritus, who suggested that material objects are made of tiny, elementary, indestructible particles. The particles of each type were imagined to be identical and indivisible, hence the name "atom", from the ancient Greek *atomos*, meaning "uncuttable".

Much later, as the 19th century dawned, chemistry experiments provided evidence that all materials are indeed made from elementary substances – hydrogen, oxygen, carbon and other elements – and that each such substance consists of identical, minuscule objects. European scientists of the time were familiar with ancient Greek philosophers, so it was natural for chemists such as John Dalton to call these objects "atoms". After some initial definitional chaos, the meaning of atom was settled by the middle of that century, referring as it does today to the fundamental unit of a chemical element.

Yet the word is a misnomer. Soon after electrons were discovered at the turn of the 20th century, it was understood that they inhabit the outskirts of atoms and can be stripped off and reassigned to other atoms in chemical reactions. Their negative electric charge is cancelled, within each atom, by a positively charged nucleus, itself also divisible. So much for atoms being uncuttable. ›

But, by then, the word "atom" had already been established. Decades of research papers and conversation had relied on the term; replacing it would be no easy matter, practically or psychologically. That is why, despite knowing atoms were divisible, scientists retained "atom" and shifted its definition. Language has staying power.

Fortunately, the fact that atoms contradict their own name is harmless, albeit amusing, because the word "atom" no longer carries the resonance it had – unless you happen to have studied ancient Greek. But other expressions in physics pose greater difficulties.

Take the word "force", widely used in ordinary English, both as a verb ("I forced the door open") and as a noun ("lifting the box required great force"). The word took on a precise scientific meaning in the late 17th century, as Isaac Newton was developing his laws of motion. He used the term to mean the amount and direction by which one object pushes or pulls on a second object, thereby affecting the latter's motion. (Often writing in Latin, Newton used the word "vis", but translated it as "force" when writing in English.) For two centuries, the meaning of "force" in physics dialect was clear because this definition conveniently overlaps with the standard, intuitive English meaning.

But trouble was brewing. Scientists learned in the 19th century that the pull of static electricity arises from something they called the electric field. A corresponding magnetic field is responsible for the pull that holds a magnet to a metal object. Soon, though, other roles for these fields, having nothing to do with pushes or pulls, were discovered. Most importantly, waves in these fields manifest as what we call light. The two fields are also at play in the emission and absorption of light by atoms and in a variety of other exotic effects.

Physicists needed a name for the entire category of these "electromagnetic" phenomena, including not only the pushes and pulls, but also light and its interactions with matter. They had a choice: either define a new term that encompasses all these processes, leaving "electromagnetic force" to mean only the pushes and pulls, or expand the definition of the older term to include them all. Regrettably, they chose both.

When talking among themselves about electromagnetic effects, physicists often use "interaction", as in: "lasers, firelight, chemistry and collisions of electrons are all caused by the electromagnetic interaction". To my mind, this word is particularly apt, and it is unfortunate that it isn't used more widely. The meaning of "interaction" in physics is close to its meaning in English, where it represents the idea of interplay or contact between people or objects that can cause a change in their behaviour.

But scientists also just use the word "force" in place of "interaction", portraying the electromagnetic force as responsible for all electromagnetic processes. This is problematic because it extends "force" far beyond our intuitive understanding of the word. For instance, they use the word to refer to four "fundamental forces": electromagnetism, gravity and the strong and weak nuclear forces. In doing so, they lump gravity's pull together with the ripples in space and time known as gravitational waves, describing them all as "due to the gravitational force".

Physicists also sometimes say things like "the weak nuclear force powers the sun and supernovae, and causes certain atomic nuclei to decay". But this can easily be interpreted to mean that these important effects occur through a push or pull, whereas they actually involve something far more remarkable than a traditional force: the transformation of a particle from one type to another.

Admittedly, the problems with "force" only go so far. It doesn't take long to highlight the two different meanings, as I have done here. The word "particle", however, takes these issues to a higher level.

Like "force", "particle" has multiple definitions in physics dialect. In one, it retains its original meaning from standard English. But it has another meaning that partially conflicts with the one we are used to. This can cause serious misunderstandings, sometimes even for scientists.

In ordinary English, a quintessential particle would be something like a grain of sand. It is a simple thing; it looks like a small dot. If thrown,

We intuitively know that a push requires force

CATHERINE FALLS COMMERCIAL/GETTY IMAGES

"Must $E = mc^2$ really be translated into words? The answer is certainly yes"

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it moves along a narrow path. If placed in a box, it will just sit there, doing nothing. Hearing that an electron is an elementary "particle", we naturally imagine it to be an even smaller dot, perhaps infinitely small, to the point of indivisibility. Our intuition for "particle" then provides us with an idea of how an electron should behave. We imagine a moving electron as a dot traveling on a narrow path. If the electron is placed in a box, whether that box be large or small, we envision the electron sitting within it, stationary, inactive.

This is indeed how scientists conceived of electrons for decades after their discovery. But we now know they aren't like this at all. Unlike a grain of sand, an electron is a tiny wave. Though its wavy nature reveals itself in many ways, let me mention just two. First, an electron in a box, rather than lying still and doing nothing, instead vibrates billions of trillions of times a second. This is wavelike behaviour: the "standing waves" formed on a plucked guitar string are familiar examples of waves that naturally vibrate and yet go nowhere. Second, waves spread out in a way that particles can't, making them sensitive to their container. An electron responds to its enclosure's shape and size. For instance, if a box with an electron inside it shrinks, the electron's energy increases.

Yet electrons aren't ordinary waves, either, because they are indivisible, unlike sound or water waves. For this reason, some physicists, going back to the 1920s, have entertained the use of the word "wavicle", which captures the idea of a minimal, indivisible unit of a wave. I personally like the term because it comes with no baggage, no pre-existing meaning in English that could confuse the hearer. Its novelty frees the mind to imagine a new concept that is neither particle nor wave. Unfortunately, the word "particle" is embedded as deeply in the language of physics as "atom" was at the turn of the 20th century, and trying to replace it with "wavicle" would probably be an unwinnable battle.

Yet the fact that particles are nothing like specks of dust is among our most foundational discoveries. We cannot let this crucial lesson be obscured by our choice of words. If the words can't be changed, we have to learn to see beyond them, to cultivate an appreciation for "elementary particles" that exceeds our intuition, and open our minds to what the word actually denotes in modern physics.

"Some physicists entertain the word 'wavicle' instead of 'particle'"

In highlighting the challenges of interpreting scientific language, I speak from first-hand experience. As a teenager, I read many books and articles about physics, and I tried to take their words at face value. I did the same when my first physics teachers used expressions that sounded familiar. But in an inverted image of my Parisian experience with music, here I found myself unable to interpret what seemed to be spoken in English. I blamed myself, at the time. It was only when I took advanced physics classes and began to build my understanding on the maths underlying the ideas that I learned the physics concepts properly. Then it became clear that unfamiliar meanings had been the problem all along.

Today, as a professional physicist, I find that scientific language poses a more subtle challenge. Despite the argument that science is mainly founded on wordless notions – empirical data, equations, thought experiments and an inspired intuition for the material world – the doing of science requires scientists to communicate. We must share new ideas and hypotheses so that they may be discussed, weighed and evaluated. As we do so, the language we use can affect our imaginations. When we hear a familiar word, our brains instantly import its conceptual baggage from standard English, packed with its connotations, associated metaphors and visual images. If it has been substantially redefined by physicists, as is the case for "particle", this baggage can be misleading, even to the point of derailing our efforts to grasp core aspects of the cosmos.

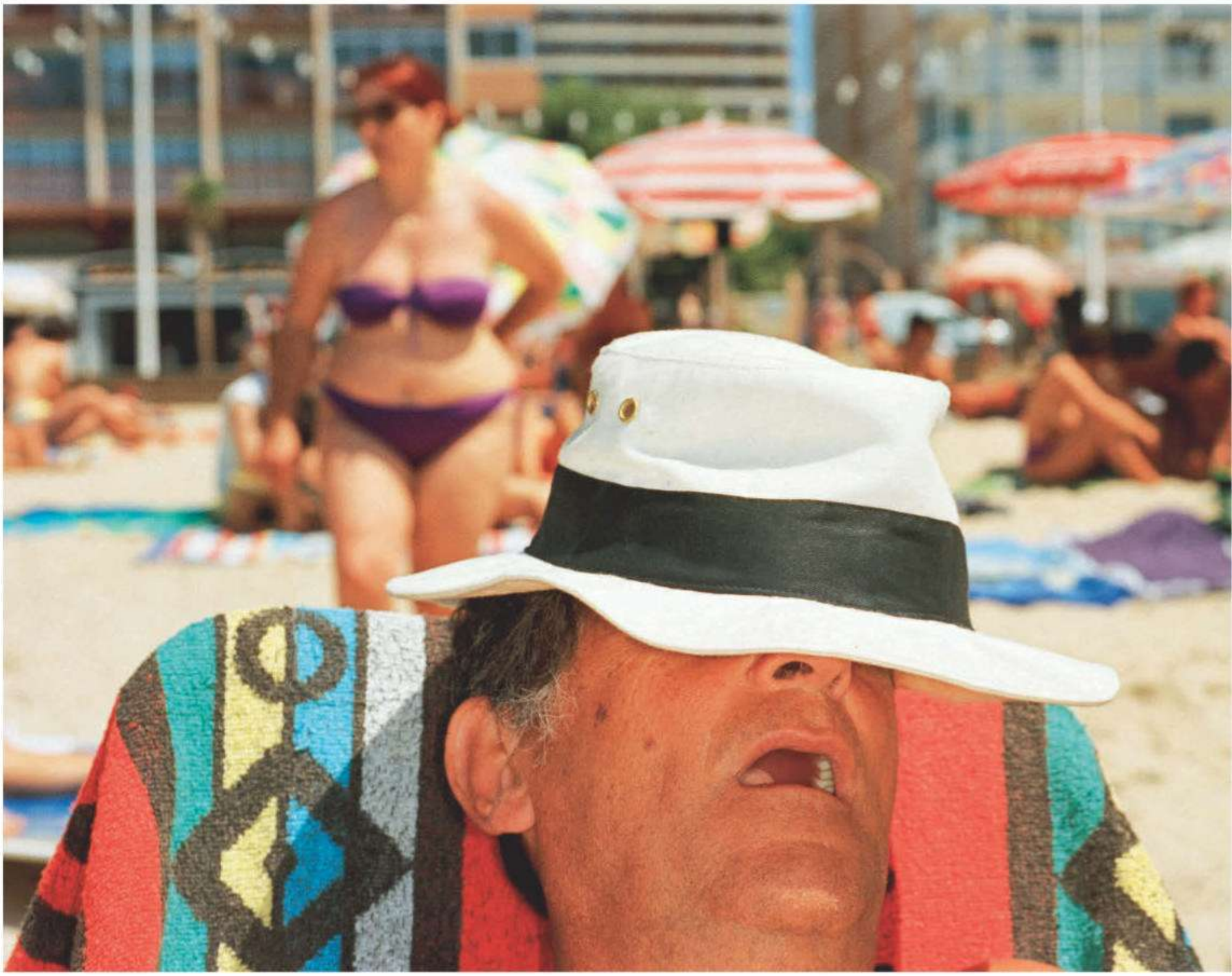
Despite my decades of experience as a particle physicist, and knowing in my heart that electrons, quarks and Higgs bosons are quite unlike grains of sand, I can't prevent my mind, upon hearing the word "particle", from promptly conjuring up an image of a tiny dot. It seems inescapable: even for experts, language affects our wordless imaginations so deeply that it can't fail to influence the way we think. Since this influence potentially interferes with our conception of nature, it is essential for us to be aware of it and to compensate for it.

Can we dream of a day when all the problems of physics dialect are resolved? Sadly, there seems little chance of this. The stories of "atom", "force" and "particle" suggest that linguistic hazards are unavoidable. As we have seen, terms that initially seem appropriate become entrenched long before they prove inadequate or misleading, by which point they are almost impossible to dislodge. Our best bet, it seems, is to appreciate the dialect's limitations and find ways to circumvent them. Only then can we clearly perceive the mysteries and majesty of our universe. ▮

We tend to think of particles as tiny, solid balls

XVISION/GETTY IMAGES

Matt Strassler is a theoretical physicist at Harvard University. His latest book, *Waves in an Impossible Sea*, is out now.



MARTIN PARR/MAGNUM PHOTOS

Bad vibrations

Snoring is often viewed as a nuisance, but as **Graham Lawton** discovers, it can also be a serious health threat – and we are finally beginning to understand why

IT HAS ruined many a night's sleep, and no doubt a lot of relationships too. Trying to sleep next to a snoring partner is exactly that: trying. Once the engines fire up, there are few countermeasures besides a shove, earplugs and the patience of a saint.

That's the thing about snoring: many of us consider it to be little more than an embarrassment or an annoyance and grudgingly put up with it. But accumulating findings suggest that this trivialises an important, and common, health problem.

Snoring isn't just associated with broken sleep, it can be a warning sign of trouble ahead and also appears to have some potentially serious impacts on the snorer's cardiovascular system. Despite a proliferation of remedies, there is a paucity of evidence about what works. But as sleep researchers increasingly wake up to the hidden dangers of snoring, there is hope the nightmare will soon end.

Snoring is very common, though getting a handle on exactly how common is difficult. Many snorers are blissfully unaware that they do it. "If you ask someone 'Do you snore?', they'll say 'I dunno, I'm sleeping'," says Danny Eckert, director of sleep health at Flinders Health and Medical Research Institute in Adelaide, Australia. "Their bed partner might tell them, but a lot of people don't have a bed partner." In Eckert's experience, however, it is rampant. "It's a huge problem," he says. "The main reason people come to our clinic is snoring."

Most formal estimates of the prevalence of snoring rely on self-reports, or those from bed partners, and vary widely in their findings, with numbers as low as 1.5 per cent in some studies and as high as 83 per cent in others. But two commonly cited numbers are that about 45 per cent of adults snore occasionally and 25 per cent snore regularly. Men are more likely to snore than women and the incidence rises with age and body mass index. Drinking alcohol, taking sleeping pills and sleeping on your back amplify the problem.

For anyone unfortunate enough to be within earshot, a snore is a snore is a snore. From a medical perspective, however, there are two categories of snorer in this world. One is people who have sleep-disordered breathing conditions such as obstructive sleep apnoea (OSA) or hypopnoea. These conditions are usually caused by the squishy anatomical structures of the upper airway collapsing under gravity. As air passes over these tissues, they vibrate noisily.

The tissue around the top of the throat may fully (in the case of OSA) or partially (in the case of hypopnoea) obstruct the windpipe, which can lead to dangerous reductions in a person's blood oxygen levels. People with severe OSA can stop breathing altogether hundreds of times per night.

Snoring is often a symptom of these disorders, but not always. Indeed, about a third of people who snore habitually don't have OSA or hypopnoea. Those in this second group are classified as "primary" snorers. The cause of their snoring is also sagging airways, but the tissue doesn't frequently interfere with the business of getting air into the lungs. The American Academy of Sleep Medicine defines it as snoring with an average of four or fewer episodes of apnoea or hypopnoea per hour of sleep – many times fewer than those with serious OSA.

While OSA has long been associated with various cardiovascular diseases, especially strokes, primary snoring was seen as much less of a threat. The most well-recognised health consequences of primary snoring included daytime sleepiness, irritability, headaches and decreased cognitive performance. Bed partners are also at risk of hearing loss, especially in the ear facing the snorer.

But there is more to snoring than just a bad night's sleep. For a long time, heavy snoring has been known to be associated with a disease called carotid atherosclerosis, where solid plaques build up on the insides of the main arteries in the neck. This is a major risk factor for strokes because pieces of plaque can come loose, float into the brain and block smaller blood vessels. The association was assumed to be with OSA, however, rather than primary snoring.

Heavy snorers

That changed in 2008 when researchers at the Westmead Institute for Medical Research in Sydney, Australia, examined the carotid arteries of a group of primary snorers and non-snorers. They found that many of the snorers had carotid atherosclerosis; the heavier they snored, the more likely they were to have it. Around two-thirds of the very heavy snorers – those who snored for more than half of a typical night's sleep – had carotid atherosclerosis.

The researchers also examined the femoral arteries in the snorers' thighs and found no sign of atherosclerosis, pointing to the conclusion that the carotid problem was specifically associated with snoring.

There was already a suggested mechanism for this: the carotid artery runs close to parts of the anatomy that vibrate during snoring and may be damaged by repeated exposure to mechanical stress. So the team exposed the carotid arteries of anaesthetised rabbits to 6 hours of snoring-like vibrations. This caused the artery walls to constrict, which is a known precursor of atherosclerosis.

The results prompted Jeremy Rich, then at the Walter Reed Army Medical Center in Washington DC, and his colleagues to dig deeper. They obtained a database containing more than 77,000 assessments of habitual snorers under investigation for OSA. Most of the people in the database did indeed ›

have OSA, but about 6000 of them didn't – and they were still at a higher risk of death. Even when the researchers excluded those with the additional risk factor of obesity, the primary snorers had 16 per cent higher mortality than expected. Exactly why was unclear. The link to carotid atherosclerosis was a possibility, as was the fact that many primary snorers have some episodes of apnoea or hypopnoea, albeit not often enough to get over the diagnostic threshold. Primary snoring can be the start of full-blown OSA or hypopnoea: some snorers in the study may have gone down that road after the test.

Since then, the noise levels around the health hazards of primary snoring have ratcheted up. In 2018, a study strengthened the link between snoring and carotid atherosclerosis, finding that primary snorers were more likely than non-snorers to have one of its symptoms: stenosis, or narrowing, of the carotid artery.

Another area of concern is metabolic syndrome (MetS), a dangerous combination of obesity, high blood pressure, abnormal lipid levels in the blood and high blood sugar. OSA is a known risk factor for MetS, but primary snoring is emerging as one too. The first hints of a connection came in the early 2000s and the evidence has built since. In 2020, a team at Shanxi Medical University in Taiyuan, China, reviewed the published evidence and concluded that primary snoring is clearly associated with MetS, though the direction of causality is unclear. It is possible that metabolic syndrome or its components cause snoring and not the other way around. People with higher BMI are more likely to be snorers, for example.

But one component of MetS is emerging as a particular worry for primary snorers: high blood pressure, or hypertension, which is a major risk factor for cardiovascular and kidney disease. In 2018, Serge Brand at the University of Basel in Switzerland and his colleagues published a study of 181 adults aged 40 to 60 who had been referred to a sleep clinic at Kermanshah University in Iran because of difficulties breathing while asleep. They all spent a night in the sleep lab to be assessed for OSA and have their blood pressure measured.

When the researchers crunched the numbers, they found that those who were diagnosed with OSA were more likely to have hypertension. But so were primary snorers.

The study was admittedly small, but a much larger dataset confirms this finding. Earlier this year, a team led by Eckert's colleague Bastien Lechat, also at Flinders Health and Medical Research Institute, recruited more than 12,000 middle-aged people, mostly men, who had suspected OSA. Crucially, the participants were already using a Withings Sleep Analyzer, which sat under their mattress at home and kept tabs on snoring and probable episodes of apnoea and hypopnoea. They were also keeping track of their blood pressure.

Devices such as these are revolutionising the study of primary snoring, says Eckert. Before they came along, snoring was hard to get good data on, even during OSA assessments in a sleep lab. "We didn't measure snoring very well or quantitatively," he says. "It was largely just, did they snore, yes or no? So we haven't been able to ascertain the role of snoring in and of itself with any degree of certainty." But home devices have made it possible to gather that information.

Lechat's team gathered around six months of data from each participant. Around 20 per cent of them had high blood pressure, defined as an average systolic/diastolic reading of 140/90 mmHg or above. In many cases, the hypertension could be linked to OSA, which was to be expected. When the researchers eliminated people with OSA, however, they found that primary snorers also tended to be hypertensive – they were almost twice as likely as non-snorers to exceed the 140/90 threshold.

ALIAKSANDR MAZURKEVICH/ALAMY

Cutting alcohol and smoking is advised to help stop snoring, but there is little strong evidence that it works

Snoring isn't just associated with broken sleep, it can be a warning sign of trouble ahead

New Scientist Live

Cold cases: Genetic genealogy meets history and forensics
Find out how Turi King uses the latest DNA technologies to answer previously impossible questions **newscientist.com/nslmag**

On average, their blood pressure readings were 6 mmHg higher than non-snorers. This is clinically significant, says Lechat: for people aged 40 to 69, an increase in systolic blood pressure of 20 mmHg, or diastolic blood pressure of 10 mmHg, more than doubles the risk of dying from stroke or heart disease.

The direction of causality still isn't fully established, but it is telling that the primary snorers with high blood pressure were younger and slimmer than the average participant, says Eckert – so their hypertension couldn't be solely attributed to their age and body mass.

There are many plausible mechanisms by which primary snoring could cause hypertension, says Eckert. "You're still getting the airway muscles and structures relaxing and narrowing. Maybe it's not enough to make your oxygen levels go too low, but you're still placing extra strain on the heart and the breathing muscles and that can add up to raised blood pressure." On top of that, atherosclerosis is also a cause of hypertension because it narrows the arteries. "Snoring may be an important mechanism that contributes to hypertension," concluded Lechat and his colleagues in their paper on the study.

Noise pollution

It could also be at least partially down to something entirely different: noise exposure. This is often measured with "A-weighted decibels", or dB(A), which is a more accurate representation of the wavelengths at the middle of the human hearing range. According to the World Health Organization, nighttime sound levels in excess of 45 dB(A) – about the same as a radio playing in the background – can lead to sleep disruption, which has been identified as a possible cause of hypertension. Regular exposure to nighttime noise pollution in excess of 53 dB(A) can directly cause hypertension, heart attacks, heart failure and strokes, possibly as a result of increased levels of stress hormones.

Snorers regularly smash these sound barriers. A small study published in 2019 found that two-thirds of habitual snorers exceed 45 dB(A) and 14 per cent go higher than 53 dB(A). According to Guinness World Records, the loudest snore ever recorded was 93 dB(A). "This is incredibly loud, starting to get to jackhammer level," says Eckert.

The next step for the Flinders team is to treat primary snoring and see whether it lowers blood pressure, he says. If it does, then the arrow of causality will be firmly pointing at snoring as an independent cause of hypertension. For now, says Eckert, snorers would be well-advised to get their blood pressure checked.

All of which points to an urgent need to find suitable remedies. For OSA, the solution is sometimes surgery, but what can be done for primary snorers? In 2023, the Australasian Sleep Association issued guidelines, which included weight loss, cutting down on alcohol, sleep-position training to get snorers off their backs and bespoke mouthpieces to open their airways. More drastic measures requiring medical supervision are continuous positive airway pressure (CPAP), a ventilator-like device that keeps the airways open, and, as a last resort, surgery to the nose or soft palate to trim back the tissues that create snoring.

These are all commonly prescribed treatments, says Eckert. So is quitting smoking. But none has especially strong evidence behind it. And many of the other options on the anti-snoring menu are even less validated. "There's a heap of rubbish out there," he says.

Earlier this year, Chidsanu Changsiripun, then at the University of York in the UK, and his colleagues carried out a systematic review of the published studies investigating potential interventions. They didn't assess the strength of the evidence, but found some gaping holes in the literature. One was that there was no research whatsoever on the effectiveness of weight loss, cutting down on alcohol and quitting smoking.

Bed partners are at risk of hearing loss, especially in the ear facing the snorer

"Several behavioural interventions have not been assessed, even though they have long been widely advisable for snorers," says Changsiripun, now at Chulalongkorn University in Bangkok, Thailand. Another was that very few of the studies assessed the impact on snorers' sleeping companions, even though "bed partners are often the most impacted by snoring", says team member Catriona McDaid at the University of York.

This general paucity of evidence is probably down to the fact that primary snoring isn't – yet – seen as a major health hazard, says Eckert. If it were, there would be more research on how to stop it.

For now, the snoring-afflicted will need to make do with the little available evidence. But Changsiripun is on the case. "Our findings will support future systematic reviews to compare all treatment options for efficacy and safety," he says. "Thus, for those interested in which treatments have the strongest evidence for the best-suited therapy, please stay tuned for more definitive conclusions." ▮

CPAP ventilator-like devices can help stop snoring by keeping the airways open

NO_LIMIT_PICTURES/GETTY IMAGES

Graham Lawton is a staff writer at *New Scientist*

"We need to think differently about artificial intelligence"

Will AI ever emulate human intelligence? Professor of machine intelligence **Neil Lawrence** tells Alex Wilkins it is misleading to compare the two

WHAT sets humans apart from the rest of life, or indeed inert matter? Many people would respond that it is our intelligence. Yet the rise of seemingly intelligent machines challenges this way of thinking. The companies behind these new artificial intelligence technologies, in the form of ChatGPT and its rivals, speak of achieving artificial general intelligence – machines that have the same level of intelligence as humans across a range of tasks.

Does this meteoric rise in AI make human intelligence, and therefore us, less special? Neil Lawrence, professor of machine learning at the University of Cambridge, doesn't think so. In fact, he thinks we should throw out the concept of artificial general intelligence altogether.

In his new book *The Atomic Human: Understanding ourselves in the age of AI*, Lawrence makes the case that it is only by better understanding our own intelligence, and how wildly different it is to its artificial counterpart, that we can make the most of both. Here he tells *New Scientist* why he thinks both human and artificial intelligence are misunderstood, why it is pointless to compare the two and why, ultimately, we need a more nuanced understanding of intelligence.

PAUL RYDING

Alex Wilkins: What do you make of the trend to compare artificial to human intelligence?

Neil Lawrence: Most of these arguments are pointless, they are irrelevant. Of course, the nature of the intelligence that we're seeing in AI is extremely different from our own. It's absurd that people are talking about this intelligence as if it's anything to do with us. But as humans, we can't help but anthropomorphise it because that's the way we try to communicate and understand.

It's interesting because there was this tradition at one point where, every summer, newspapers published formulas for beauty – consisting of some absurd combination of numbers to try to unpick beauty. The discussion of intelligence, as if it's rankable and quantifiable, is just as absurd. We wouldn't talk about artificial general beauty, so we shouldn't be talking about artificial general intelligence.

There are aspects we can talk about. I can talk about the intelligence of a particular decision, as long as I know the context and what the individual was trying to achieve. But if the context isn't present, then trying to turn it into a rigorous scientific definition, or trying to claim that we can rank general intelligences, or that there's such a thing as an artificial general intelligence, is absurd and dangerous.

Scientists have puzzled over how to define intelligence for a long time. Are we any closer to a satisfactory definition?

In my book, I use the term intelligence a lot, but I try to move away from that and towards information processing as an idea. I think we can now start looking at rigorous definitions of intelligence that are based on information, because information is fundamental.

Large distributed systems process information. The ecology that's around us is doing that, and our culture does that too – we're a distributed intelligence. Arguably, the seat of human intelligence is actually in our culture, rather than in individuals.

Do you have an example of this kind of distributed intelligence?

Social insects are a form of distributed intelligence. Where I am at the moment, in southern Italy, there are a lot of ants because the weather has been very dry. These ants seem special in that they form multiple nests. We get these columns of ants moving into the house and then moving out again and going from one nest to another. It's really extraordinary watching them moving eggs. Just as we think we've dealt with one nest and one column of ants, the next day there's a column that's ›

"I'm sceptical about the things people are saying about artificial general intelligence"

SHUTTERSTOCK/VALERIYA ZANKOVYCH

arisen from somewhere else, following the old path and coming into the house again.

My mother-in-law says, "wow, they're really intelligent". Of course, individually they aren't really intelligent: they don't have planning systems that are looking ahead a long way and making strategic decisions about how things might pan out, which is a quality of human intelligence. But the ants are making decisions about where they should go to acquire resources for the nest, and those decisions take place in a distributed manner through ants communicating when they have found a pile of sugar or laying down scent trails. Any sensible definition of intelligence needs to include components of information processing.

Presumably, a similar principle applies to humans. What does that tell us about the nature of intelligence more broadly?

The ants are an information processing system, but then when you see them you also start to realise that so is the whole ecosystem around us. Information is stored in DNA, and plants, animals, bacteria and archaea all react to changing circumstances, making decisions. Those decisions affect multiple generations. Arguably the AI we've created has more in common with the ants' processing of information than human processing. But we anthropomorphise ants in the way we anthropomorphise AI.

These systems are quite hard for humans to think of as intelligent because they don't manifest in the way that our intelligence manifests. Our intelligence is a distributed intelligence, but it's distributed in this weird way where our communication bandwidth as humans is very narrow and our computational capabilities are enormous.

This gives us each a sense of ourselves within a community, as an entity, as an individual. When we're communicating with others, we also think of them as individuals and as entities. I think this makes it harder for us to sometimes see the distributed nature of our intelligence. It's also harder for us to recognise distributed intelligences, and for us to recognise intelligences that are information processing systems operating over time frames that are much, much longer than the time frame over which we're operating, such as over millions of years.

Do you have an example of this kind of intelligence?

Life on Earth is an information ecosystem that's operating over millions of years. It responds to plate tectonics and other events that occur on geological time scales. For example, flowering plants started to dominate other species around 100 million years ago, about 100 million years after the last supercontinent, Pangea, began to break apart. Perhaps in another 100 million years, these plants will be faced with the challenges of surviving what happens when the Earth's land masses form a future supercontinent.

These are timescales that are very difficult to imagine because information is passed to our offspring through our genome hundreds of millions of times slower than a conversation between two humans shares information. Similarly, we find computers' information processing difficult to conceive because they share information hundreds of millions of times faster than we can.

What, then, should people make of the latest AI systems, like ChatGPT, which certainly seem impressive at first glance?

I'm sceptical about the things people are saying about artificial general intelligence. I think it is dangerous to talk about things in those terms because we don't have a good definition of intelligence. But despite that

NewScientistLive

Hear more from Neil Lawrence at this year's New Scientist Live. He will be speaking on 13 October about the ways human intelligence differs from artificial intelligence and why our fears of being displaced might be misplaced.

For more information, visit
newscientist.com/nslmag

SHUTTERSTOCK/NOIZ STOCKER

scepticism, with the technology we already have, even if you pause all development today, AIs are utterly transformational because they represent an information revolution.

People are saying, "oh, it's going to have orders of magnitude greater intelligence". For comparison, as I go from walking to driving a car, that gives me about an order of magnitude increase in speed. From a car to a plane, that gives me another order of magnitude increase in speed. That's a 100-fold increase. But really, the big transformation is in AI's information access rate – the rate that two machines can communicate with each other – which is 300 million times greater than human-to-human communication.

That's the big transformation. It's just got nothing to do with this idea of artificial general intelligence, which is a nonsense.

This transformation seems like it has the potential to upset a lot of the established players, like Google, Amazon, Microsoft and so on. How do you think that will play out?

For the first time we've got a technology – that isn't perfect by any means and needs a lot of work – where regular humans can talk to the computer and instruct the computer directly. So a regular human, without having to learn programming languages, can ask the computer about the information that the computer has access to.

This is incredibly exciting and incredibly dangerous at the same time because the computer has the potential to misrepresent, as it is already doing, whether that's on purpose or just the nature of the way the AI models have been built. But it also has the possibility to give individuals access to a collaborator, where the collaborator is not a human, but a machine that has access to this vast amount of information. This is transformational, giving individuals access to that information 300 million times faster rather than through a world curated by Google, Microsoft, Amazon or Facebook.

All the big tech companies are the ones that point the spotlight on where the information is. What's interesting is that, currently, big tech is incentivised to persist in the way that they've been dominating the information infrastructure. But now they have to make sure they're not disrupted by the capability of individuals to access the machine directly.

What aspects of intelligence are machines still lacking?

I think the really interesting one is lack of motor skills. It's remarkable that all the things we've managed to get the computer to emulate

AI is more like the distributed intelligence of ant colonies than human intelligence

are all the sorts of things that scientists think of as useful and important, like doing maths or playing chess or playing Go.

But when it comes to what regular people enjoy – playing football, having a good gossip, being a friend to a friend in need – all those things are part of our intelligence. Perhaps these are part of our intelligence that scientists, who are maybe not the most socially engaged of the human species, haven't valued as much. All those pieces are incredibly difficult to emulate, but particularly the motor skills. It's not to say that we won't get there, but it feels like we won't.

So where does all this leave us, with regard to how we think about our own intelligence?

There's an iconic picture of Earth taken by astronauts on the Apollo 17 spacecraft in 1972. This blue marble photo became a symbol of the environmental movement, because Earth looks like a massive, extraordinary place when you're on it, but when you stand off it, you realise that it's a really special, complex, extraordinary thing that needs looking after.

I'd like the same thing to happen when you stand on this other intelligence. It will and already does have capabilities that are well beyond anything humans can do. This doesn't mean that it replaces us, but it does mean that it's an interesting place to stand and reflect on ourselves – what we actually want – and try to lift our thinking as a species.

And will AI ever have human levels of intelligence?

Well, those capabilities, in some sense, are critically dependent on our limitations. Our ability to see things, to make decisions, is dependent on our vulnerabilities and our limitations, and we'll never be able to emulate that in machines because machines don't have those limitations baked in and never will.

The fact that we're going to die, the fact that those close to us can die, we can be betrayed by other humans, we can lose our reputation – it's these things that a computer can't experience that make us special. It is these things that make human intelligence unique. ▮

Alex Wilkins is a news reporter at *New Scientist* focused on physics and technology

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Picturing the lighter side of life p48

Debunking gardening myths

Grow it yourself?

Is it really cheaper to cultivate your own fruit and vegetables? **James Wong** isn't convinced and does the maths to find out

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek

IT IS an article that seems to come around every year: the promise that the average family can save money by growing their own fruit and vegetables. Whether they echo "dig for victory" wartime nostalgia or romantic pioneer spirit, the writers never really reference how they arrived at the stats they use. So can your average home gardener really compete on price against the economies of scale of industrial agriculture? Let's crunch the numbers.

Say you want to start with one of those bucolic, wooden potato-growing planters you see in gardening catalogues. In the UK, these cost around £75. Given potatoes in my supermarket are £0.90 per kilogram, that planter would have to produce at least 83kg of spuds for me to break even, before we even talk about the cost of the seed potatoes, the growing medium, fertiliser, tools and water. Assuming you get similar yields per square metre as the professionals, a 60x60 centimetre container would only give you around 2 to 3kg per year. So at best, you would only just recoup your investment after around 27 years.

What if you dispense with the fancy kit and just shove some potatoes in garden soil? Well, given that saving potato tubers to start off new crops is restricted in many countries to prevent the spread of plant viruses, you will still need to start by buying seed potatoes. In my garden centre these don't come cheap, at about £9 per kilo. While it is true that for every kg of seed potatoes you buy, you can get a harvest of up to 10kg, that ultimately only reduces the cost to around the same per kg as my supermarket spuds. For easy-to-transport produce with long shelf lives, like potatoes, carrots and onions, it really is almost impossible to get the maths to work in your favour on a domestic scale, as efficiencies resulting from agricultural mechanisation make these so inexpensive to buy.

SHUTTERSTOCK/TG23

However, when it comes to more delicate offerings, the reverse is often true. As these highly perishable crops tend to be laboriously (and expensively) harvested by hand, they can be some of the most costly to buy. And the three most expensive items in my supermarket produce section also happen to be the easiest to grow. Gram for gram, herbs like chives (pictured) are over 50 times the cost of spuds and come from varieties that can crop for half a century from a single planting. Many other herbs like mint, dill and fennel are so resilient that much of the gardening advice is how to prevent them from taking over your plot.

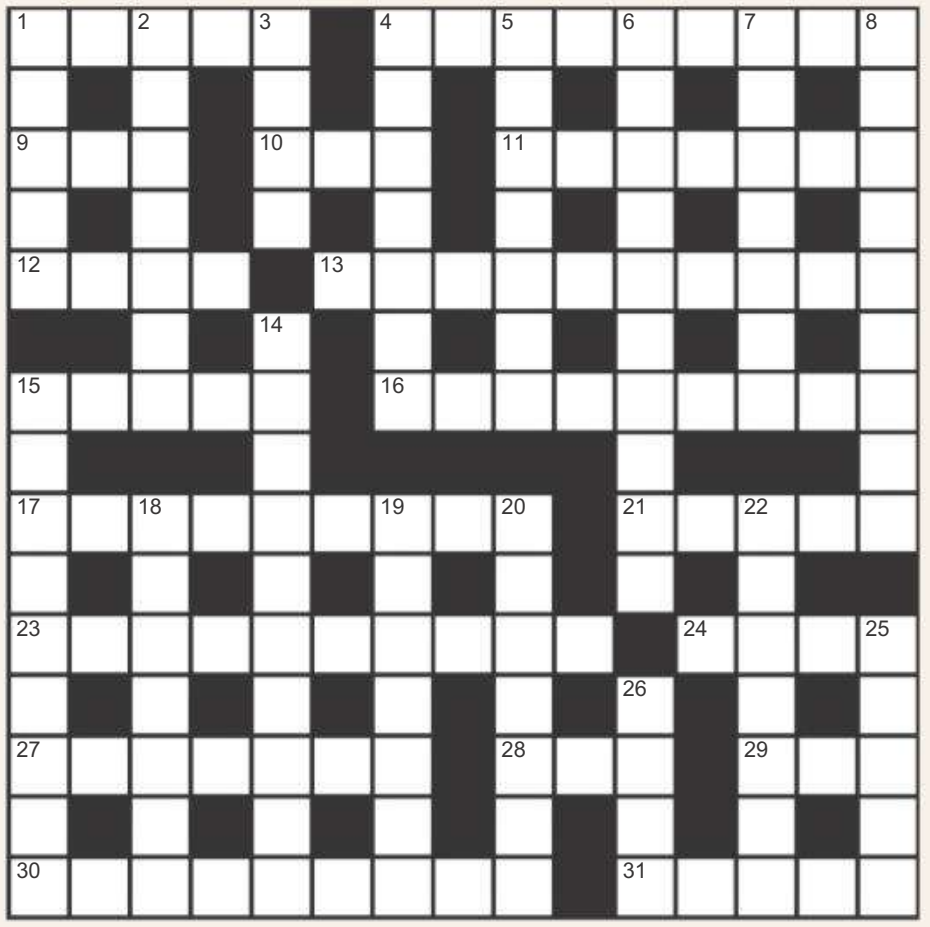
This is also true for pricey salad crops like wild rocket, or arugula, which lives a secret double life as a common garden weed, and for delicate berries like raspberries and blackberries, whose plants' rugged constitution doesn't extend to their fruit. But these are, it turns out, the exception to the general economic reality. ▮

Debunking gardening myths appears monthly

Next week
Science of baking

These articles are posted each week at newscientist.com/maker

Quick crossword #167 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 90 degrees (5)
4 Disease of the liver (9)
9 Wildebeest (3)
10 Charged particle (3)
11 Having the capacity to dissolve (7)
12 Ore deposit (4)
13 Edible aquatic plant (10)
15 Stephen Jay ___, palaeontologist and essayist (5)
16 Invention of Alexander Graham Bell (9)
17 Occuring at a delayed stage (4-5)
21 2^3 (5)
23 African ape (10)
24 Ova (4)
27 Rust, perhaps (7)
28 Combine (3)
29 Execution command, in computing (3)
30 Designed for efficiency and comfort (9)
31 Highest single-digit ordinal (5)

DOWN

1 Star in Orion (5)
2 Tumorous nasal swelling (7)
3 Castor or Pollux, say (4)
4 1985 Carl Sagan novel (7)
5 Supposed UFO crash site in New Mexico (7)
6 Rotary-wing aircraft (10)
7 <0 (3-4)
8 Document providing details of a machine or material (4,5)
14 Adhesion of particles to a surface (10)
15 Monosaccharide sugar (9)
18 Winding around (7)
19 Solar ray (7)
20 Concerning temperature (7)
22 Yuri ___, Soviet Cosmonaut (7)
25 Electronic musical instrument (5)
26 Nerve fibre (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #270
set by Bethan Ackerley

1 Bioluminescence can be created by which class of oxidative enzymes?

2 What type of variable stars have historically been helpful in calculating the rate of expansion of the universe?

3 Animals like frogs and sharks respire using their throat and cheek muscles in a method known as what?

4 What is the name of the English town where Louise Brown, the first person to be conceived by in vitro fertilisation, was born?

5 Which of these metals is considered the least reactive: magnesium, beryllium or calcium?

Answers on page 47

BrainTwister
set by Christopher Dearlove
#38 Rotating dice

Put a cube on a surface and trace a square around its base. How many ways can you place the cube flat on the table and perfectly within the square so that its faces are oriented differently?

Imagine an axis going through the middle of two opposite faces of the cube. You can rotate it around this axis by 90 degrees, and the cube would take up the same space (but in a different orientation). How many different axes are there going through the cube where you can do this with some rotation less than 360 degrees?

For each of these axes, by which angles is it possible to rotate through and get back to a cube taking up the same space? Count the total number of possible rotation angles over all the axes (including the case of not rotating the cube, but only once).

Consider the number of ways to place the cube, and the total number of ways to rotate the cube, relative to the number of edges on it. Is this the same for other regular shapes used for dice? What other kinds of shape does this work for?

Solution next week

Going down

Cycling on hilly roads, what is the best option to save energy: go as fast as possible downhill to gain momentum for the next climb, or stop pedalling to have a rest and regain some strength?

Hillary Shaw
Newport, Shropshire, UK
Without air or friction, and if every hill were the same height, a cyclist would need no energy input – downhill speed would just take them up the next hill. Rollercoasters work a bit like this.

But in reality there is friction and air, and the faster you travel, the more energy goes into overcoming these things. So, you should freewheel down and save your energy for the next hill. As you slow down, pedal to boost your uphill speed and delay slowing so much that you must dismount.

Steve Willey
London, UK
Freewheel. Save your energy.

Having ridden a bicycle from Bogotá in Colombia to Lima in Peru, among other moderately hilly excursions, I am intimately familiar with this conundrum.

Unless the resultant climb is short, there is no point in wasting energy by pedalling on the

"Cyclists sometimes pedal downhill because the psychological benefit of making progress is worth the effort"

descent, as gravity on the climb will get you very soon and you usually need all the energy you can muster. Additionally, you rarely get just a hill, singular, on your journey. There is always another one waiting just over that brow unless you are cycling somewhere flat where the wind will probably get you anyway.

Having said all that, I would rather cycle uphill all day than cycle into a headwind all day.

SIMON GROSSET/ALAMY

This week's new questions

Eye of the beholder **What makes something beautiful?**
Garry Trethewey*, Cherryville, South Australia*

Question of scale **Could there be a universe larger than ours, such that ours is a subatomic particle by its standards? And is it possible that, within the particles we know of, there are smaller universes?** ***William Wood****, Charlbury, Oxfordshire, UK*

Chris Daniel
Glan Conwy, UK
When going downhill, it is tempting to pedal as fast as possible to maximise speed and therefore kinetic energy, which can be translated into potential energy in the subsequent ascent. This may not be the best strategy.

Cyclists are aware that the greatest source of drag is aerodynamic resistance. The power output required to overcome it rises with the cube of velocity, so a lot of additional effort is needed for only a small gain in speed. For example, going from 22 kilometres per hour to 25 km/h is a 14 per cent increase in speed, but it requires 47 per cent more power.

At this speed, wind resistance amounts to 70 per cent of the total drag – the rest includes rolling resistance between the tyres and the road, mechanical frictional forces in the drive train and axles, and gravitational resistance. However, when going at a more sedate pace up a hill, the gravitational force will predominate.

Fortunately, most bikes have a wide range of gears. It is sensible to take advantage of gravitational acceleration when going downhill by pedalling in high gear at an increased speed, but with no more than your normal power, so that you aren't additionally battling increasing aerodynamic resistance, tiring yourself out before the ascent ahead of you. The acquired kinetic energy will take you uphill until your speed has decayed to a point at which you can change to a lower gear and continue pedalling at a hopefully manageable power output to the top.

Ian Cairns
Seaford, East Sussex, UK
The best option to save energy is to stop pedalling. The additional kinetic energy gained by pedalling downhill is less than the total energy expended, as energy is increasingly lost in overcoming air resistance, which is proportional to speed. Still, cyclists often pedal downhill because the psychological benefit of making progress on the next hill is often worth the extra effort. Also, if the previous uphill has been a long slog, it can feel good to "warm down" the legs by pedalling downhill – and, of course, going fast can be fun in the right situation!

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What features make us find one thing beautiful and another thing ugly?

Coprolific

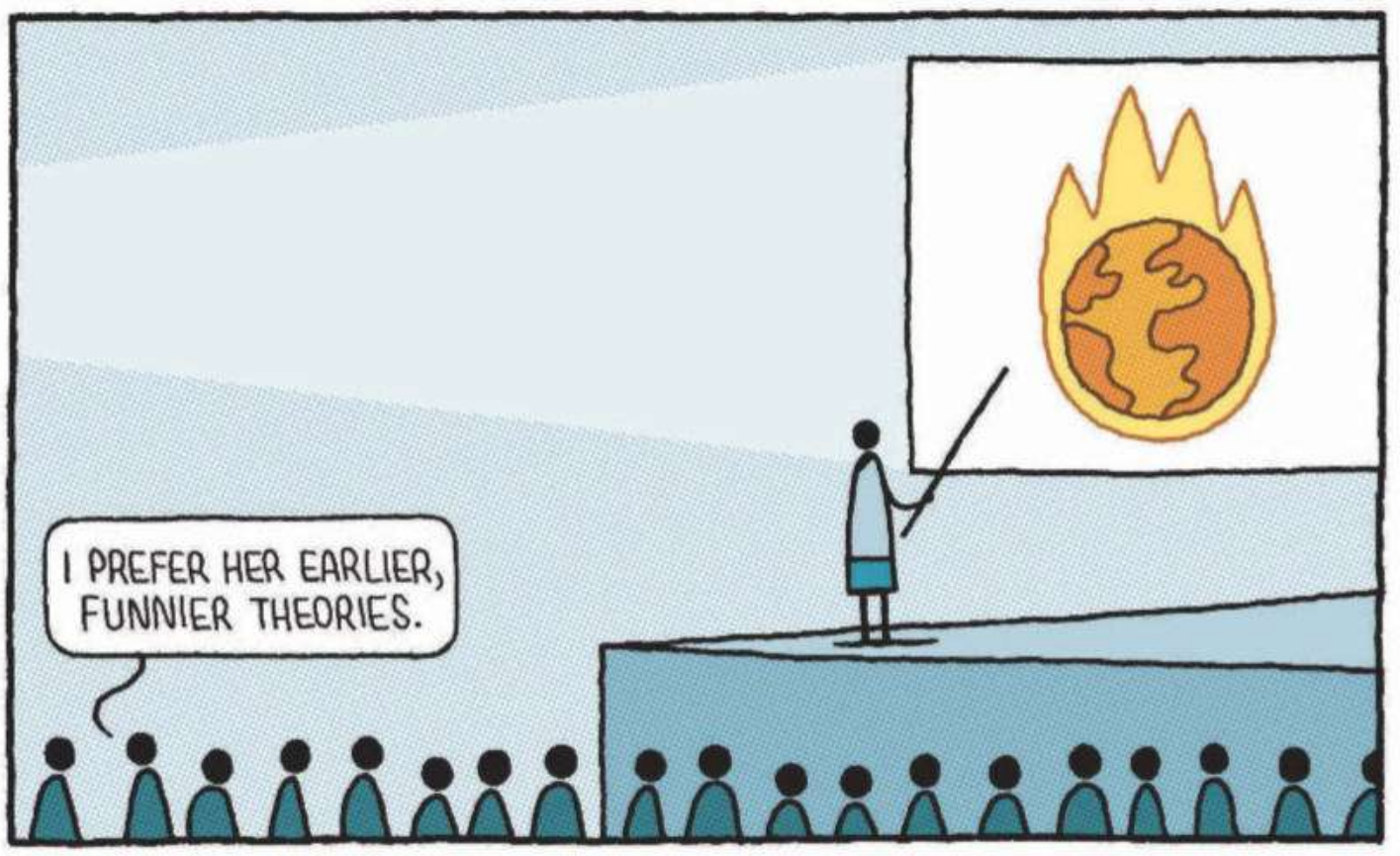
The reign of the dinosaurs lasted around 180 million years. Where, exactly, is 180 million years' worth of dinosaur poo?

Ron Dippold
San Diego, California, US
The polite term for a fossilised poop is a coprolite.

We do find the occasional coprolite, and in many instances they are highly prized because if you find them next to a cache of fossils or eggs, you can tell what creatures like dinosaurs were eating, even by accident. Meat, plants, seeds, pollen – the things we find in coprolites are very important in deciphering what the environment looked like at that place at that time.

Unfortunately, coprolites are relatively rare for the same reason that poop lying all over the place is relatively rare today. Why is that? First, it is a precious food source for insects. As soon as an animal does its business, insects are all over it like flies on... poop. Besides flies, there are many larger insects

Tom Gauld
for New Scientist



like dung beetles that also covet it.

If the insects don't take care of it, rain usually washes it away. Poop is far more fragile than bone. To turn into a coprolite, a poop needs to be in a very quickly mineralising environment, like a mudflat, in which it sinks down to a point where most insects can't get to it and minerals can sink into it to make a rocky crust and preserve it.

So, thankfully, everything conspires against poop hanging around and what survives from that time is now, ironically, precious – like anything else you hang on to long enough, like flared disco pants. And I am certainly not trying to say "poop" as many times as I can in the distinguished pages of *New Scientist*.

Mike Follows
Sutton Coldfield, West Midlands, UK

The short answer is, everywhere: in the soil, the atmosphere, all the flora and fauna surrounding us, your furniture, clothes and food. No doubt there are atoms in your body that were once part of many dinosaurs – and their poo. Every time you drink, you are sampling dinosaur urine, and every breath you take will include air that has been through the lungs of many dinosaurs, and belched and farted by them too.

"Every time you drink, you are sampling dinosaur urine, and every breath you take will include air farted by dinosaurs"

Living organisms are part of a food chain, web or ecosystem. Most simply, plants are consumed by herbivores, which are predated by carnivores or omnivores, which can become prey in turn. Even if a living organism avoids consumption or predation, it will die of old age.

The dead body decays, broken down by the work of decomposers, so that all the material is recycled as nutrients or biomass for the growth of living organisms, though the material isn't always broken down to the atomic level before it is recycled.

In the meantime, any poo (in the case of animals) or other waste (such as leaf litter from trees) will be recycled in the same way. Detritivores, which include millipedes, flies, earthworms and dung beetles, ingest dead organic matter and detritus (including poo) and break it down. Bacteria and fungi like mushrooms are examples of saprotrophs. They excrete enzymes that break down detritus so that they can absorb it.

Imagine if decomposers were all simultaneously wiped out. The rapid accumulation of poo and other waste would be very unpleasant. Our decomposers really do deserve a better press.

Lighting up

Is it feasible to start a fire with a fart and a static spark from human hair?

Andrew Cuthbert
Perth, Australia

Why ask us, Jed? Let us know how you go! ▮

Answers

Quick quiz #270 *Answers*

1 Luciferase
2 Cepheids
3 Buccal pumping
4 Oldham
5 Beryllium

Cryptic crossword #144 *Answers*

ACROSS 8 Hadrons, **9** Imago, **10** Rains, **11** Adipose, **12** Cotyledon, **14** Dam, **16** Tow, **18** Metronome, **21** Centaur, **22** Tweak, **23** Carat, **24** Wide-set

DOWN 1 Shortcut, **2** Adrift, **3** Moss, **4** Island, **5** Pimiento, **6** Canoed, **7** Mole, **13** Lambaste, **15** Meerkats, **17** Wintry, **19** Thrown, **20** Odense, **21** Coca, **22** Tidy

#37 Digital multiplication *Solution*

Starting at 93, we get 93 ⇨ 27 ⇨ 14 ⇨ 4. To find the sequence of length 5, work back from 8, which comes from multiplying the digits of 18, 81, 24 or 42. To get 18, the prior number needs to be 29, 92, 36 or 63, as the non-trivial factors of 18 are 2, 9, 3 and 6. This stops when a number isn't the product of two single digits, so rule out 29 (all primes are ruled out) and 92. To get 36, you need 49, 94 or 66, of which only 49 works; 63 could come from 79 or 97, but both are prime. Since 49 is the product of 7 × 7, the sequence goes 77 ⇨ 49 ⇨ 36 ⇨ 18 ⇨ 8. For three digits, we must avoid 0, or a 5 paired with an even number, as these end the sequence early. 688, 868 and 886 give 6-long sequences. Rearrangements of 679 also produce sequences of length 6, ending in 6.

Ten unexpected things were honoured at the 34th Annual Ig Nobel prizes last week, each so extremely surprising that, in the event's long tradition, it makes people laugh, then think.

The awards gala happened at the Massachusetts Institute of Technology, in a lecture hall filled with paper airplanes thrown by audience members respectful of the Ig Nobel tradition of recycling paper by bringing it along and turning it into disposable aircraft.

Peaceful pigeons

This year's Ig-winning achievements span a wide range of human, botanic and other behaviour, some of it avian.

Before one commits to using live pigeons to guide the flight paths of missiles, one might want to do experiments to learn the feasibility of housing them inside a missile nose cone. In the 1940s, psychologist B. F. Skinner undertook such experiments. He was awarded, posthumously, this year's Ig Nobel peace prize.

Skinner's daughter Julie attended the ceremony, where she accepted the prize on his behalf. B. F. Skinner was a giant in the field of behaviourism. Years after the pigeons-in-a-missile experiments, he wrote: "Something happened during the brief life of Project Pigeon which it has taken a long time to appreciate. The practical task before us created a new attitude toward the behavior of organisms."

Plants' sense of style

A similar major readjustment of attitude could result from the work of 2024's Ig Nobel botany prize winners Jacob White and Felipe Yamashita. They found evidence that some real plants imitate the shapes of neighbouring artificial plastic plants. Details appear in their study "*Boquila trifoliolata* mimics leaves of an artificial plastic host plant".

Marjolaine Willems and her colleagues collected the anatomy prize, for studying whether the hair on the heads of most people in the northern hemisphere swirls in the same direction (clockwise or counterclockwise) as hair on the heads of most people in the southern hemisphere.

Details of that are in their paper "Genetic determinism and hemispheric influence in hair whorl formation".

Passing wind

Countless metaphors and turns of phrase relate to the research that earned the physiology prize for Takanori Takebe and his colleagues. The team discovered that many mammals are capable of breathing through their anus.

Persistence paid off for the probability prize winners František Bartoš, Eric-Jan Wagenmakers, Alexandra Sarafoglou, Henrik Godmann and about 50 colleagues, many of them students. Together they showed, both in theory and by 350,757 experiments, that when you flip a coin, it tends to land on the same side as it started.

Painful placebos

Lieven Schenk, Tahmine Fadai and Christian Büchel copped the medicine prize for demonstrating that fake medicine that causes painful side effects can be more effective than fake medicine that doesn't cause painful side effects.

(Their study brings memories of, but doesn't explicitly cite, a paper by Dan Ariely and his colleagues that won the 2008 medicine prize for demonstrating that high-priced fake medicine is more effective than low-priced fake medicine.)

Jimmy Liao was awarded the physics prize, for demonstrating and explaining the swimming abilities of a dead trout. In a series of papers he writes about discovering this unexpected aspect of fluid dynamics.

Drunk worms

Worms can be sober. Worms can also, if they imbibe alcohol, become sloshed. Tess Heeremans, Antoine Deblais, Daniel Bonn and Sander Woutersen won the Ig Nobel chemistry prize for devising a method to use chromatography to separate drunk and sober worms.

A prize for research in demography – the statistical study of human populations – went to Saul Justin Newman for his detective work as to whether demographers notice important details. Newman discovered that many of the people famous for having the longest lives lived in places that had lousy birth-and-death recordkeeping.

Newman wrote two papers about this. He gave each a title that tidily explains how conclusions get leaped to. One is called "Supercentenarians and the oldest-old are concentrated into regions with no birth certificates and short lifespans". The other is "Supercentenarian and remarkable age records exhibit patterns indicative of clerical errors and pension fraud".

This year's collection of Ig winners finishes with a bang. Fordyce Ely and William E. Petersen were posthumously awarded the biology prize for an experiment they did in the 1940s. The duo exploded a paper bag next to a cat that was standing on the back of a cow, to explore how and when cows spill their milk.

Ely's daughter Jane and grandson Matt came to the ceremony, where they accepted the prize and witnessed a demonstration that involved a toy cat, a human in a cow costume and five Nobel laureates exploding paper bags. ▮

Marc Abrahams, Ig Nobels founder

Twisteddoodles *for New Scientist*

I'M A BODY OF RESEARCH
SCIENCE
MY BODY IS WEIRD AND WONDERFUL
SCIENCE
IT'S ALL LASERS, SPACE, COMPUTERS AND CURES ONE MINUTE
SCIENCE
THEN IT'S "WE GOT SOME WORMS DRUNK, AND PUT A PIGEON IN A MISSILE" THE NEXT
SCIENCE
@twisteddoodles

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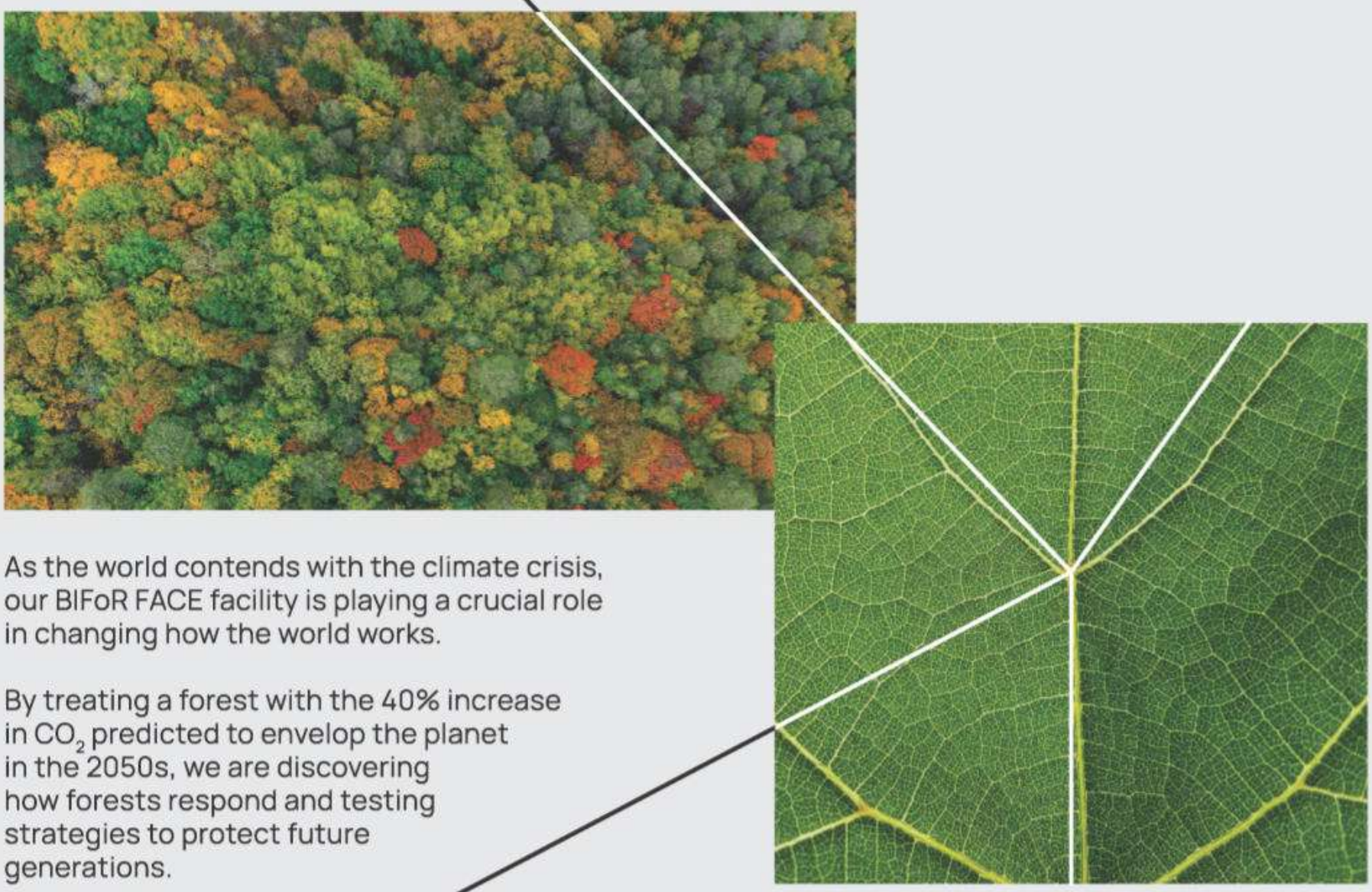
Revealing the effects of climate change on forests of the future



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